march 1959

nlgi spokesman

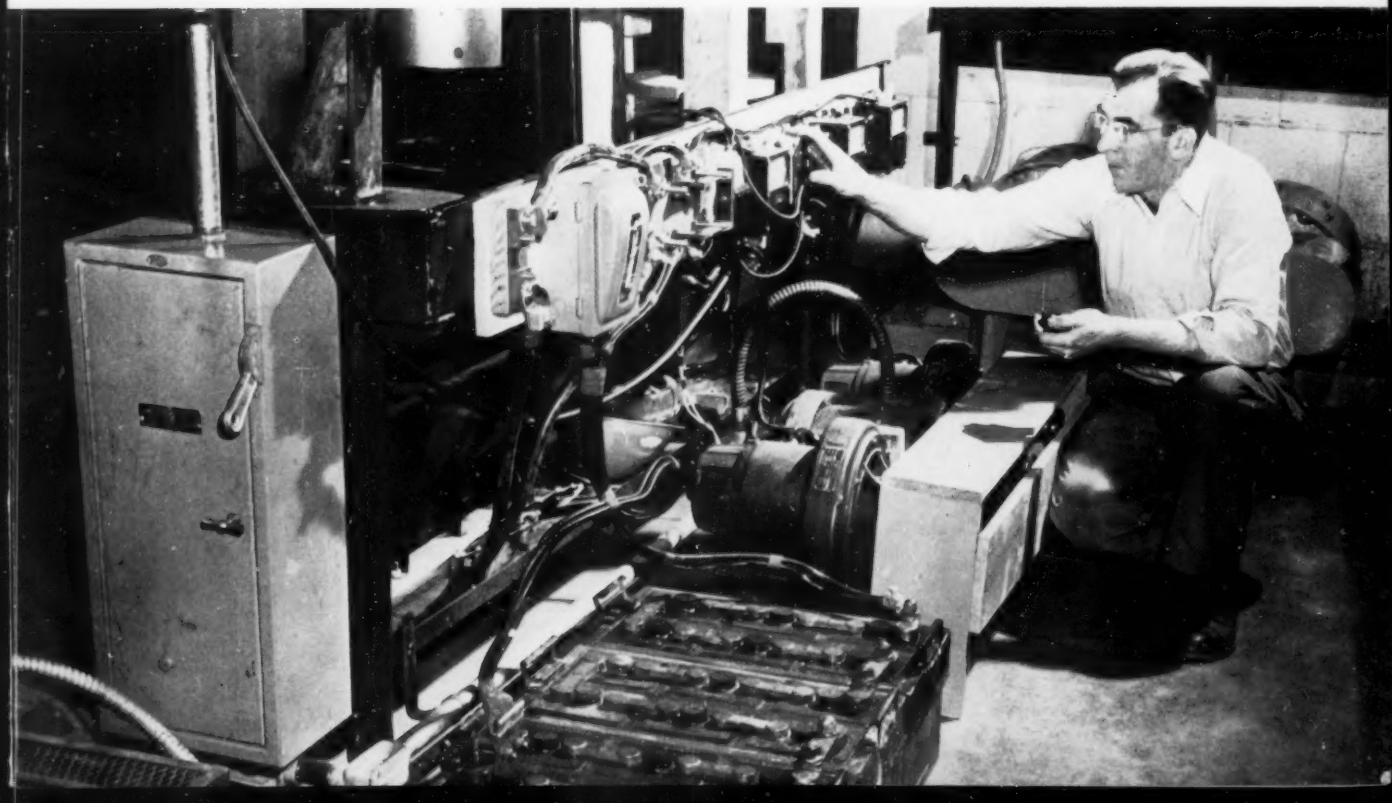
journal of the national lubricating grease institute

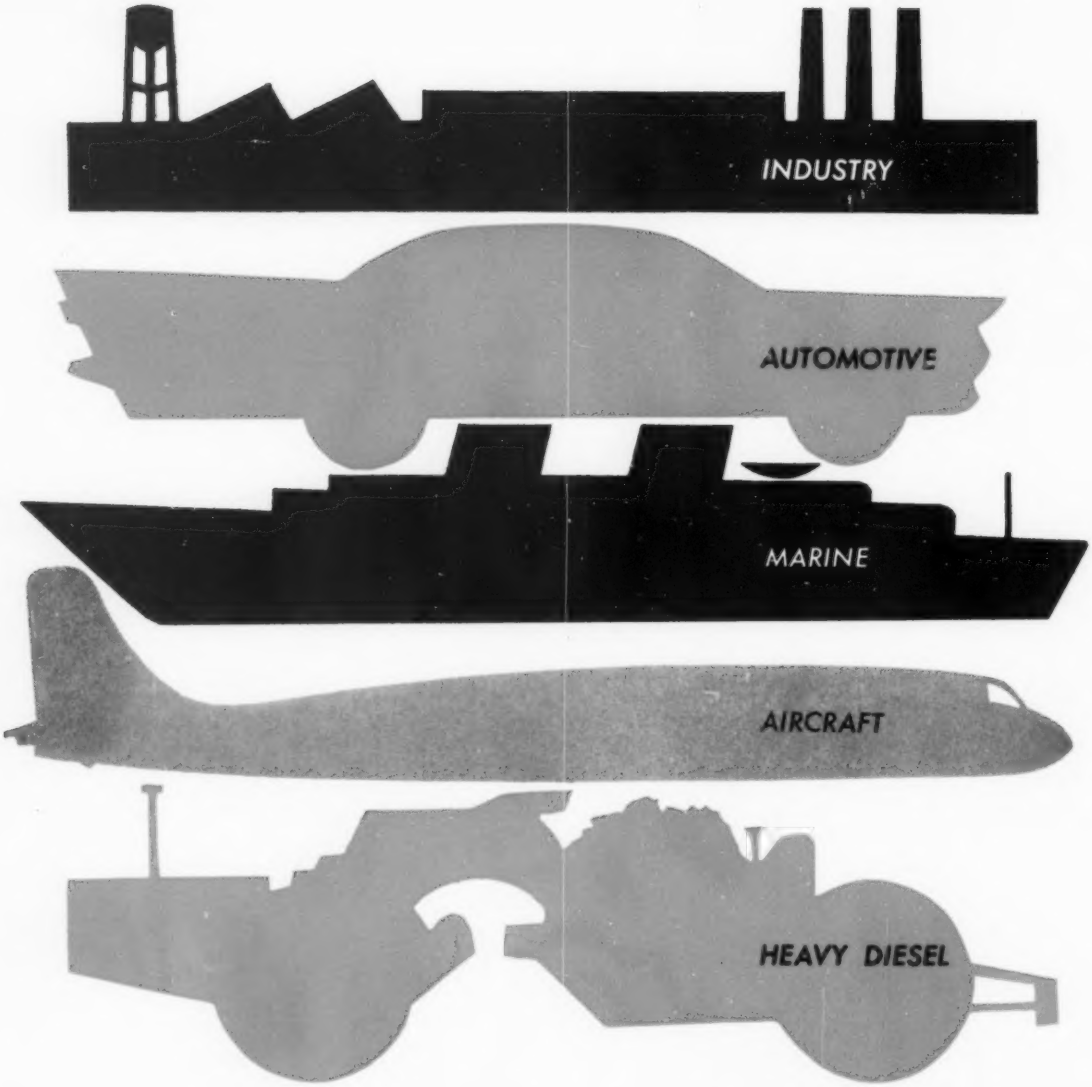
A Preformed Organic Thickener for Lubricating Greases
By J. E. KLINE, W. L. HAYNE, JR., and T. P. TRAISE

Ball and Roller Bearing Lubrication
By R. S. BARNETT

Two Tons of Grease
By J. W. WAITE

NLGI SPOKESMAN Index
VOLUME XXII, APRIL, 1958—MARCH, 1959





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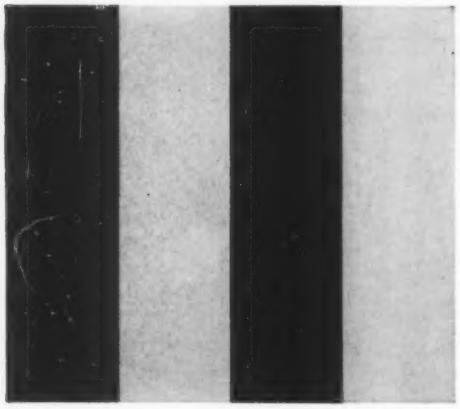

News About NLGI

Returns for NLGI Second Survey Ahead of Last Year

Although exact totals were not disclosed, officials of Ernst & Ernst, advised that returns of questionnaire forms for the second NLGI production survey were " . . . well ahead of this time last year." This would indicate the second production survey of lubricating greases and fluid gear lubricants, for the year 1958, will have an even higher total of participants than the 1957 compilation . . . NLGI's first.

The anonymous forms are returned to Ernst & Ernst, the gathering agency, where they are tabulated and destroyed. The closing date is March 31 and all classifications of Institute membership will receive the data, as it is furnished the national office, by Ernst & Ernst, by mid-April.

Some 76 per cent of the membership replied in the first survey. This year an even larger group representation is expected, in addition to the totals of Canadian Active member firm, which will be represented for the first time.

J. L. Carroll is New NLGI Fellow

NLGI's research fellow at the graduate school of the University of Utah for the past three years, Sang Joon Hahn, has completed the work on his doctorate and returned to his native Korea. Dr. Hahn is familiar to many in the Institute for his work in thixoptrophy, the reports on which he made to members at two NLGI annual meetings.

The present recipient of the fellowship, Mr. Jimmy Lee Carroll, is now constructing a rotational viscometer (Weltman type) to study the thixoptropic properties of lubricating grease. He is also studying the flow properties of grease under pressure, using the apparatus constructed at the graduate school and reported on in part by Dr. Henry Eyring, dean of the graduate school, at NLGI's last annual meeting. It is hoped that a report can be made on the results obtained using the rotational viscometer and the high pressure viscometer at the annual meeting in New Orleans, next fall.

Maintained since 1951, the research fellowship sponsored by NLGI was designed to building a pool of scientific knowledge, as insurance of manufacturing progress for the industry.

Revised Printing of "Recommended Practices" Now Available

NLGI's popular *Recommended Practices for Lubricating Automotive Front Wheel Bearings* is once again available. The sixteen-page booklet first offered in 1954 was temporarily suspended while a technical sub-committee re-evaluated it in light of recent advances. When *Recommended Practices* was found to be up-to-date, its fifth printing was authorized and it is again offered to members and the public at cost.

The booklet was made available in 1954 after three years of preparation by volunteers within the industry. Four successive printings were made and over 120,00 copies of *Recommended Practices* have been distributed throughout the world. Heavily illustrated with photographs and diagrams, the booklet can be imprinted with company indentification and given as a training or public relations item at low cost. The NLGI national office will be pleased to answer inquiries.

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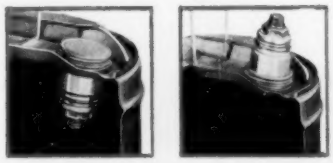

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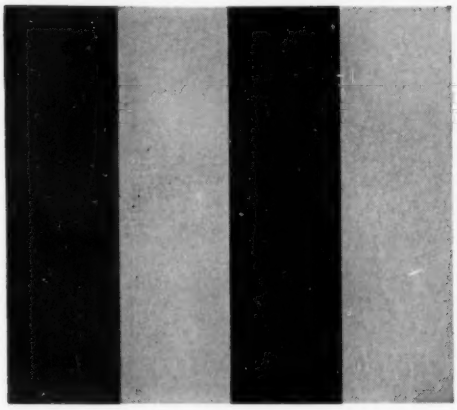


NLGI PRESIDENT'S PAGE

By F. E. ROSENSTIEHL, *President*

The Importance of Our Liaison

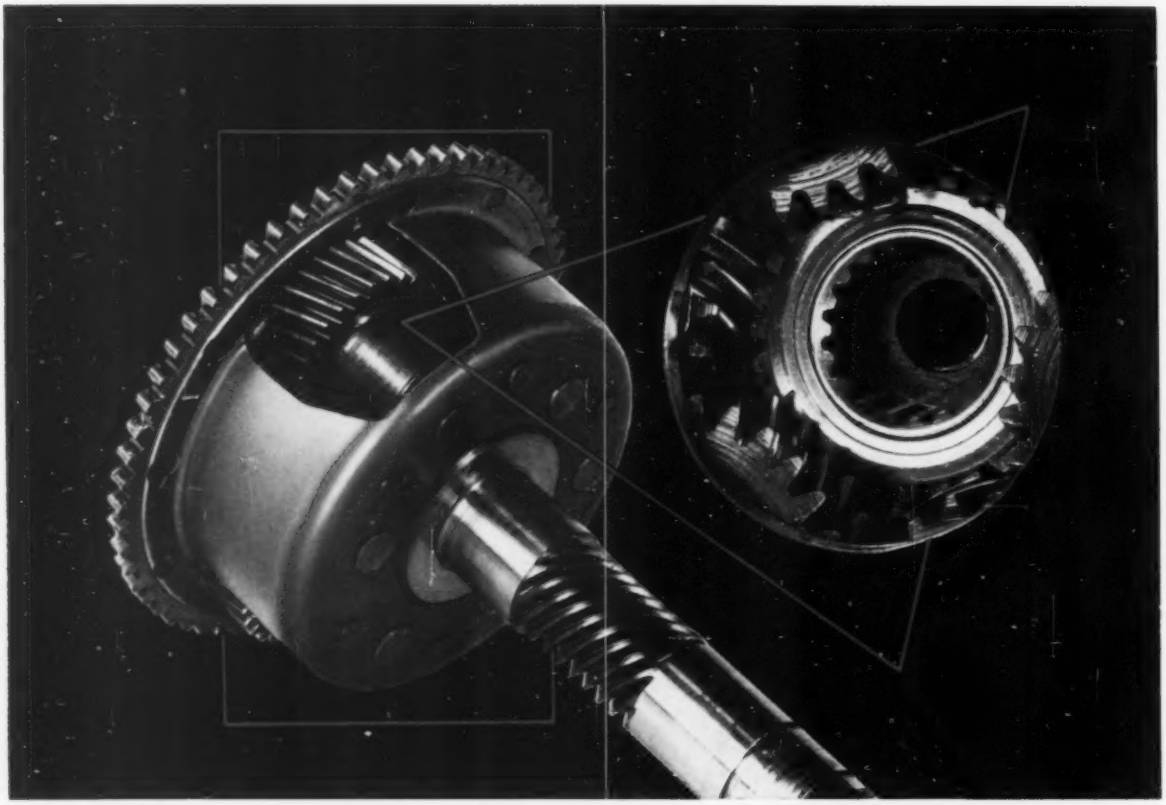
Since only a few of the members may realize NLGI maintains an active working agreement with a number of other professional societies, perhaps this is an appropriate time and place to say something about these arrangements. The purpose of maintaining such liaisons is, of course, to be sure that various groups, sharing common interests, are familiar with NLGI activities and we with theirs. This not only allows for a healthy exchange of information, but prevents each of us from working at cross purposes.

This liaison is primarily maintained by those members of NLGI's Board of Directors who also hold membership and interest in the other societies. Societies which this liaison exists include—

Society of Automotive Engineers, including their Subcommittee on Construction & Industrial Machinery Technical Committee.
American Society of Testing Materials
American Standards Association
American Society of Lubrication Engineers
American Society of Mechanical Engineers
Independent Oil Compounders Association

In the past much good has come from our working arrangement with these societies and it is hoped even greater benefits will be derived in the future. Benefits range from such spheres as use of a common nomenclature to describe various types of greases, to the establishment of standard procedures in measuring grease consistency.

Each NLGI member who may be an active member in any of the societies listed above should make every effort to improve the liaison arrangement between the societies. An active cooperation between the members of such professional groups can go a long ways in eliminating double standards or duplications and in promoting general good will.



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Two ADM sperm oils you should know more about are ADM 45° (N.W.) and ADM 38° (N.W.). N.W. is short for Natural Winter, and refers to processed oils from which solid spermaceti wax has been removed. The temperatures indicate maximum cloud points.

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IN THIS ISSUE

News About NLGI 526

President's Page 529

A Preformed Organic Thickener for Lubricating Greases 533
J. E. Kline, Amoco Chemicals Corp. and W. L. Hayne, Jr., and T. P. Traise, Standard Oil Co. (Indiana)

Ball and Roller Bearing Lubrication 537
R. S. Barnett, The Texas Co.

Two Tons of Grease 548
J. W. Waite, Inland Steel Co.

NLGI Spokesman Index 552
Volume XXII, April, 1958-March, 1959

Literature and Patent Abstracts 556

Future Meetings 558

People In the Industry 562

Industry News 564

THE COVER

THIS month's cover photograph is also Figure 12 in the article "Ball and Roller Bearing Lubrication" by R. S. Barnett. It depicts an aircraft retractable landing light assembly with associated electrical equipment necessary to operate the landing light at temperatures down to −100°F. This was some of the equipment used in a study investigating the field of extreme low temperatures in which an intense program was carried out to note the degree of correlation of torques measured by simple laboratory bench rigs with the results obtained on full scale aircraft accessories at temp. down to −100°F.

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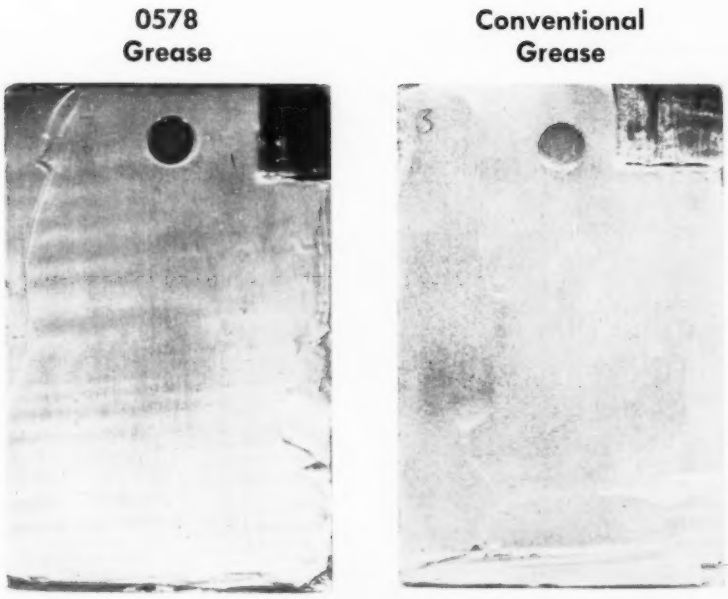


FIGURE 3, showing results of thin film tests

A Preformed Organic Thickener for Lubricating Grease

By:

J. E. Kline
Amoco Chemical Corp.

W. L. Hayne, Jr.
Standard Oil Co.
(Indiana)

T. P. Traise
Standard Oil Co.
(Indiana)

Presented at the NLGI 26th annual meeting in Chicago, October 1958

Introduction

UNTIL THE LAST decade, most thickeners for lubricating greases were soaps. Nearly all the grease produced consisted of calcium, sodium, aluminum, lead, or barium soaps of long-chain fatty acids. Classical grease research centered on the differences in properties of greases caused by changing the metallic or acidic constituent of the soap and by varying manufacturing methods (2). Recent industrial and military needs for greases capable of operating over a broader temperature range–particularly at higher temperatures– have spurred research to seek better thickeners, oils, and additives.

Most of the required improvements in lubricating greases can best be achieved by the development of new types of thickeners. Fundamental grease properties are controlled largely by the thickener. Enough different oils are available to meet most operating conditions if used with a suitable thickener. Additives complement the desirable features of the thickener-oil combination, but cannot completely change the nature of the grease.

Preformed Thickeners

Within the past few years, there have been concentrated efforts to provide preformed thickeners for grease manufacture. By using a preformed thickener, manufacturers can eliminate unsatisfactory batches and produce a uniform, high-quality product with a minimum of effort and quality-control expense. Making a batch of grease with preformed thickeners is generally faster than forming thickener *in situ*. This saving in manufacturing time means increased production and better scheduling of equipment.

Several new materials have become available as preformed thickeners. Clays, silicas, paint pigments, phthalocyanines, and other high-melting substances have been found useful. Because the surfaces of some of these products are oleophobic, they must be modified to improve oil compatability and water resistance. Others require the use of solvents to aid in dispersing them.

Recently, thickeners of a new type were developed (3). They were entirely organic and provided greases with multi-purpose characteristics suitable for use at temperatures as high as permitted by the constituent oils. These thickeners were formed directly in the oil by reacting amines and isocyanates to form substituted ureas–chemically and thermally stable solids of high melting point. Not all of the ureas have the cystalline structure necessary to make them efficient thickeners of lubricating oils. Some, although effective thickeners, do not produce mechanically stable greases. A few were found that thicken effectively in low concentrations and exhibit good water resistance. Greases prepared with these thickeners have met with wide acceptance.

The notable success of these thickeners led to research aimed toward the development of preformed substituted ureas. A study was carried out to determine if such a thickener could be preformed simply and then be easily dispersed. The result of this investigation was a new product called Thickener 0578.

This preformed thickener is a unifom, pale yellow, granular solid with a bulk density of 25 lbs. per cubic foot. As shown by the electron micrograph of Figure 1, the thickener granules have a fiber network. Three properties make this thickener outstanding for the preparation of lubricating grease. Because it is nondusting, it is easy and safe to handle. It is prewet with oil, so it mixes with additional oil easily. No solvents or special additives need be incorporated to obtain the most effective dispersion.

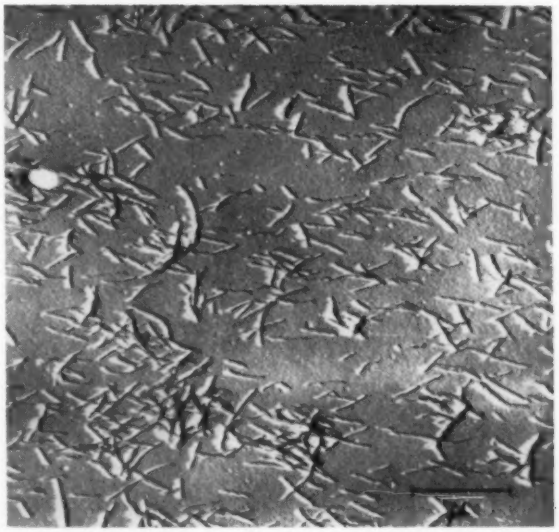


FIGURE 1, electron micrograph: Fibers in thickener 0578

Making Grease from Preformed Thickeners

Conventional grease-making equipment can be used in making grease from the preformed thickener. Two methods of manufacture are suitable: one employs a steam-heated pressure-kettle at 325°F; the other, an open fire-kettle at 395°F. Water aids dispersion in either method.

In the pressure-kettle method, all the thickener and water (5 per cent of thickener weight) are combined with one-half to two-thirds of the oil in a sealed steam-kettle. The batch is heated to an internal pressure of 65 psi and held for 15 to 30 minutes before venting. The rest of the oil is then added, and the batch is fed

TABLE I

Comparison of Greases from Pressure-Kettle and Open-Kettle Methods

	Pressure-Kettle	*Open-Kettle*	*Open Kettle (Diluted)*
% Thickener	20	20	16
Penetration			
60 Strokes	285	250	285
100,000 Strokes	300	265	300
% Leakage	1.0	0.5	1.5

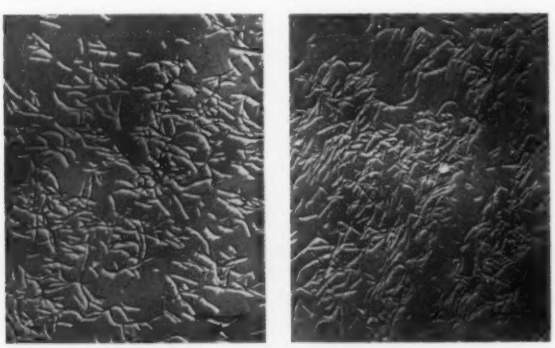
through a homogenizer or colloid mill to give the finished grease. The temperature for finishing is not critical and will normally be 100° to 250°F.

In the open-kettle method, the thickener, water, and oil are charged as for the pressure-kettle method. On heating, the water is removed by evaporation. A second, small addition of water when the grease reaches 265°F serves to further disperse the thickener in the grease. The batch is heated to 395°F, held for 30 minutes, and finished as in the pressure-kettle method.

The only significant difference between the products is the heavier consistency produced by the heat-treating period at 395°F in the open-kettle method. As shown in Table I, diluting the heavier grease with 20 per cent more oil gives a product of the same consistency as obtained in the pressure kettle. If the grease made by the pressure-kettle method is heat-treated at 395° for 30 minutes, the same 20 per cent saving in thickener is obtained. Longer heating gives no additional benefit. The slightly higher leakage of the diluted sample is probably due to its lower thickener content.

Properties of Grease from Preformed Thickeners

Greases prepared by either method are uniform, bright, and feathery. The electron micrographs in Figure 2 show that the fibers in a finished grease are similar in both size and shape to those of a lithium multi-purpose grease. An NLGI No. 2 grease prepared in solvent-extracted oil of 75 SSU at 210°F has a drop point of about 480°F. These products exhibit multi-purpose properties. Conventional laboratory tests were used to evalute thermal stability, water resistance, mechanical stability, oxidation stability, leakage, and compatability with other greases.



0578 Grease Lithium Grease

FIGURE 2, electron micrographs: Fibers in two greases

Thermal stability was evaluated in the CRC L-35 bearing test, aircraft-actuator test, and thin-film panel test.

In the bearing test, at 10,000 rpm, a grease made with the new thickener gave remarkable bearing life:

°F	*Hours*
250	2500+
300	700+
350	250

Rarely does a petroleum-oil grease perform this well, particularly at the higher temperatures.

In the aircraft-actuator test, this grease lubricated an actuator screw at 375°F, under a 200-lb. load, for 2600 cycles. Conventional multi-purpose greases function only about 50 cycles.

Thin films of this grease and conventional grease, before and after five days of exposure to air at 350°F (1), are shown in Figure 3 (located on opening page of article). Grease from the preformed thickener was still grease-like and had nearly the same worked penetration as it did before the test. The conventional grease had hardened and cracked.

Good water resistance was provided by the thickener. The grease absorbed 100 per cent or more water without impairing its structure or consistency. In the ASTM Water-Washout Test, there was no grease loss. In the water-stability test of specification MIL-G-10924A, a sample containing 10 per cent water softened only 6 per cent after 100,000 strokes.

The mechanical stability of this grease proved excellent. In the ASTM worker, the grease softened only 5 points after 60 strokes and 14 points after 100,000 strokes. After 4 hours in the Roll-Stability apparatus, it softened 5 points; after 500 hours, only 45 points. Most greases become fluid in less than 200 hours.

Good oxidation stability was imparted by low concentrations of conventional inhibitors. In the ASTM oxidation-stability test, the pressure dropped 2.5 pounds per square inch in 100 hours. Even after 400 hours, the pressure dropped only 9 pounds.

Little oil leakage was observed in the cone-and-beaker test and the pressure test of Federal Standard No. 791. The ASTM wheel-bearing test (D 1263-53T) at 250° showed only a trace of leakage and no grease loss.

The compatability with large amounts of widely different contaminating greases proved remarkable.

TABLE II
Compatibility of 0578 Grease

Contaminating Grease	Drop Point, °F	Mechanical Stability, Pen. Change After 100,000 Strokes	Mechanical Stability, Pen. Change After 4-Hour Roll Stab.	Leakage, % Loss	Wheel-Bearing Loss, g.
None	480°	14	5	3.0	0.3
50% Lithium	410°	31	2	4.4	0.3
50% Hydrophobic Silica	480°	−18	−31	3.3	0.7
35% Sodium	425°	-	21	3.8	2.7
25% Calcium	450°	-	19	3.1	16.1

The results of compatability tests are shown in Table II. Even conventional calcium grease, with a temperature limitation of 175°F, was tolerated satisfactorily to 25 per cent concentration with little change in drop point. For all four greases, the drop point remained at 410°F or above with up to 50 per cent contamination. Even with high concentrations of lithium, silica, or sodium greases, good results were obtained in the mechanical-stability tests, the cone-and-beaker leakage test at 212°F, and the 250°F wheel-bearing test.

Greases manufactured with this new preformed organic thickener are truly multi-purpose. By the prudent choice of oils and additives, both multi-purpose and specialty greases may be formulated to meet the most exacting conditions.

Conclusion

This preformed thickener provides a convenient and safe way for grease manufacturers to prepare quality greases. It will be particularly advantageous to the small manufacturer with limited technical resources. The problems of making a uniform product, batch after batch, do not arise in simply dispersing the preformed thickener. Moreover, making better use of kettle time becomes really important when one has few kettles to draw upon.

In the future, greases will probably have to meet even tougher demands of industrial and military users. In developing such greases, the convenience of preformed thickeners suggests that they will play an increasingly important role. Making an aryl-substituted urea available as a preformed thickener is a notable step in this direction.

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About the Authors

W. L. Hayne, Jr. *received his BS degree in chemical engineering from the University of Louisville in* 1947 *and an MS degree in chemical engineering at the same time. Hayne had interrupted his work at the university to serve with the U. S. Navy as an officer aboard a submarine from* 1943 *to* 1946. *He joined the research department of Standard Oil company (Indiana) in January*, 1948, *where he is presently employed. Mr. Hayne is a member of Sigma Tau, Theta Chi Delta, AIChE and ASLE.*

T. P. Traise *received his BA degree in chemistry from Blackburn college in* 1950 *and his MS in chemistry from De Paul university in* 1955. *He was employed as a chemist in the research department of Victor Chemical works from* 1950 *to* 1956. *He joined Standard Oil Co. (Indiana) in* 1956 *as a chemist in their grease research and development group. Traise is a member of ACS and ASLE.*

J. E. Kline *received his BS degree in mechanical engineering from Wayne university in* 1936 *and the degree of MS in mechanical engineering from the University of Michigan in* 1937. *After completing his graduate studies, Mr. Kline was employed for several years in the research department of Standard Oil Co. (Indiana). In* 1945 *he joined the company's sales technical service department where later he became division director, Stan-Add additive division. He was transferred to Amoco Chemicals Corp. when this wholly owned subsidiary was formed in January*, 1957. *He then assumed his present position in Amoco's Marketing dept. as mgr., petroleum additives.*

Ball and Roller Bearing Lubrication

Reprinted from the August 1958 Magazine Lubrication

By R. S. Barnett
The Texas Company

THE TURN OF the twentieth century was achieved smoothly in the engineering sense, as the common usage of rolling-element bearings dates back to about 1900.[1] Since that time these essentially simple antifriction devices have been developed to a high degree of performance in a multitude of specialized designs.

Children continue to roll along on ball-bearing skates, but the layman has little conception of the diversified applications of antifriction bearings in the world today. Such would be brought home to him if he could see with X-ray eyes into his household appliances, car and lawnmower. Electric motors turn easier, automobiles roll easier, and hand mowers push easier because of antifriction bearings at critical points. And in commerce, our industrial plants, trains, buses, trucks and airplanes use rolling-element bearings by the millions.

Modern ball and roller bearings are part of a team; the other part is the lubricant. The bearings could not do their jobs if it were not for the highly developed greases and oils that lubricate and protect them in service. This issue of magazine *Lubrication* describes advances in ball and roller bearing (BRB) lubrication during recent years.

Why Antifriction Bearings Need Lubrication

An ideal antifriction bearing would be one in which only pure rolling motion was encountered. However, this does not work out in practice. In service and under load, uncaged balls or rollers rub or slide somewhat against themselves. When a separator or cage is present, the rolling elements slide against this, and the cage itself rubs against any guiding flange surfaces.

The rolling elements may also show relative slip against the raceways. For instance, when a ball under load rolls in a curved groove, such as a curved bearing raceway, pure rolling is obtained only along two lines in the contact area; other parts of the ball slide or spin along areas of the groove to some extent. This is because the *effective* radius of the ball is smaller at points distant from the bottom of the race groove. Because the *effective* radius of the ball is smaller at wear and friction. Loading intensifies this condition.

Nature of Grease Lubrication

The great majority of rolling-element bearings are now lubricated with grease.[1] Being a solid when not under shear, grease forms an effective collar at bearing edges, sealing against dirt and moisture, and minimizing leakage as compared to the use of oil. Simpler housing designs are possible, and piping may be greatly reduced when grease is the lubricant.

Why doesn't grease cause excessive drag when it gets on the rolling and rubbing surfaces? Because grease becomes a fluid when intensively sheared or worked; therefore, the bearing is, in effect, lubricated with an oily film at points of dynamic contact. On the other hand properly compounded and uncontaminated greases are "thixotropic," which may be defined as softening under shear but returning to a solid when the shearing force is relieved.* It is easy to see from such a combination of properties why greases are widely used lubricants. They flow at the contact surfaces, but seal at the edges of a bearing.

It has been indicated for some time that certain prepacked, sealed or shielded rolling-element bearings, or those in which a controlled excess of grease is placed in the housing, are essentially lubricated by an oily phase which "bleeds" from the static grease to the moving surfaces.[2,3] The bearing needs more oil from the grease as the following increase: bearing size, speed, load or temperature. Even though 1/1000 of a drop of a 300 SUS *oil*† per hour will completely cover and lubricate the contacting surfaces of 15 to 50 mm bore bearings running at 3600 r.p.m.,[3] this amount must continually be replenished in operation.

On the other hand laboratory studies using dye tracers in shielded bearing lubrication have shown substantial feeding of the *grease* proper to the bearing.[4] Also, examinations of sealed traction-motor armature bearings have indicated some migration of grease from endplate reservoirs to the bearing in service. It is possible that the particular temperature-speed-vibration conditions in question affect the nature of the lubricating phase or phases fed to the bearing. Bearing and housing geometry are also factors in this situation, as is grease composition.

Higher Temperatures

There have been great increases in the life which lubricating greases now provide at elevated tempera-

1. See bibliography to identify this and subsequent numbered references.

* Greases are both thixotropic and non-Newtonian. A non-Newtonian material decreases in viscosity with *increasing* rate of shear with this effect being immediately reversible with decreasing shear rate. On the other hand, thixotropic hardening is proportional to aging time of the undisturbed grease.

† Viscosity in Saybolt Universal Seconds at 100°F.

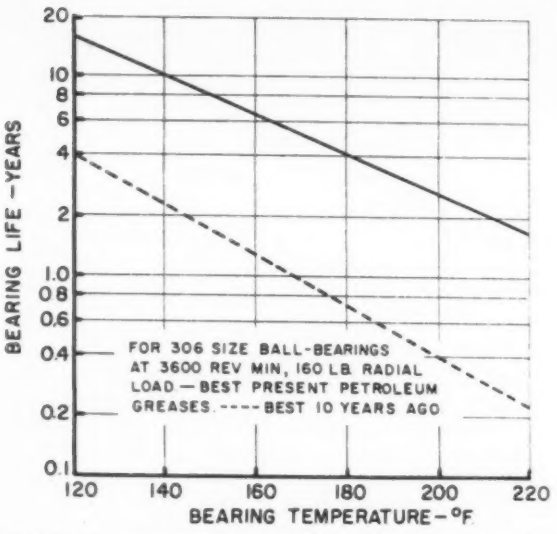


FIGURE 1, variation in grease life with temperature (reprinted from 1957 article "Recent Advances in Grease Lubrication of Ball-Bearings" by E. R. Booser[5]).

tures. This is the result of an intensive study of oxidation-resistant formulations. Such research has gone hand in hand with a fundamental study of lubricating grease structure by means of the electron microscope, X-ray diffraction equipment and optical microscopy. By means of modern knowledge the grease chemist can now scientifically arrange the lubricant structure so that improved feedability and long life are obtained.

Figure 1 shows the eight- to ten-fold increase in life at elevated temperatures which has been made

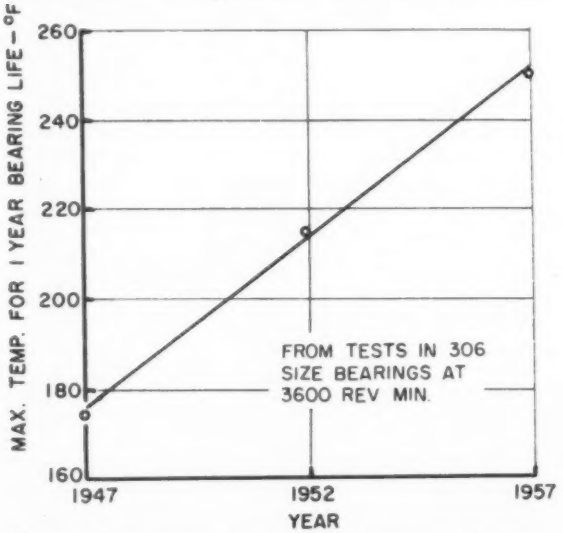


FIGURE 2, improvement in maximum temperature for petroleum greases in electric motors (reprinted from 1957 article "Recent Advances in Grease Lubrication of Ball-Bearings" by E. R. Booser[5]).

available by improved greases during the past ten years.[5] Lives predicted by these laboratory rig results may be lowered for service conditions where ambient moisture, dirt and poor maintenance are factors; however, the laboratory results are comparative among themselves and so indicate the great improvement made.

Figure 2 shows the improvement made in maximum temperature of operation for petroleum greases in electric motors during the period 1947 to 1957.[5] It may be seen that the maximum temperature for one-year "bearing life" has risen from approximately 175°F. to 250°F. The "bearing life" shown in Figures 1 and 2 is governed essentially by grease life as these were not highly loaded tests.

Considering even higher temperatures, a cooperative program at 300°F. using silicone-insulated motor/generator sets has yielded much valuable information concerning grease lubrication of No. 310* ball bearings. A comprehensive study of the factors involved, made by government laboratory personnel, indicates among other things that the design of the end-bell (which houses the reservoir grease) is important if maximum utilization of the grease charge is to be secured.[6]

Aircraft needs in particular have raised operating temperature requirements to the 450°F. and higher level. Testing at such extreme high temperatures is discussed later in this article.

Extended Temperature Range

Figure 3 illustrates the tremendous temperature range over which grease lubrication may now be achieved, as a function of general composition of the lubricant.[5] It may be seen that synthetic oily components are utilized to achieve the lowest temperatures of

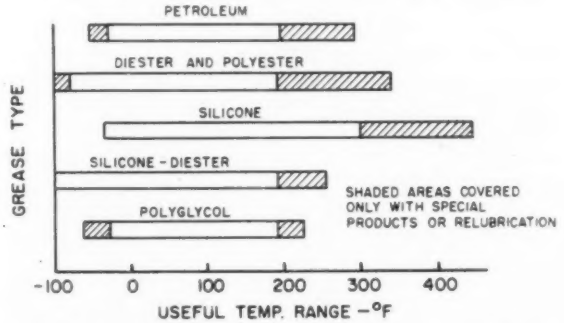


FIGURE 3, temperature range for ball-bearing greases (reprinted from 1957 article "Recent Advances in Grease Lubrication of Ball-Bearings" by E. R. Booser[5]).

* A typical ball bearing number, such as 310, conveys considerable information. For instance, the last two digits give the bearing bore number, which is 1/5 of the bore size in millimeters when the bearing bore is 20 mm or larger, thus giving a bore size of 50 mm for this bearing. The digit 3 is related to the outside-diameter series which is also related to the load capacity of the bearing. However, it is necessary to consult tables to find the outside diameter and width of bearings of a certain series.

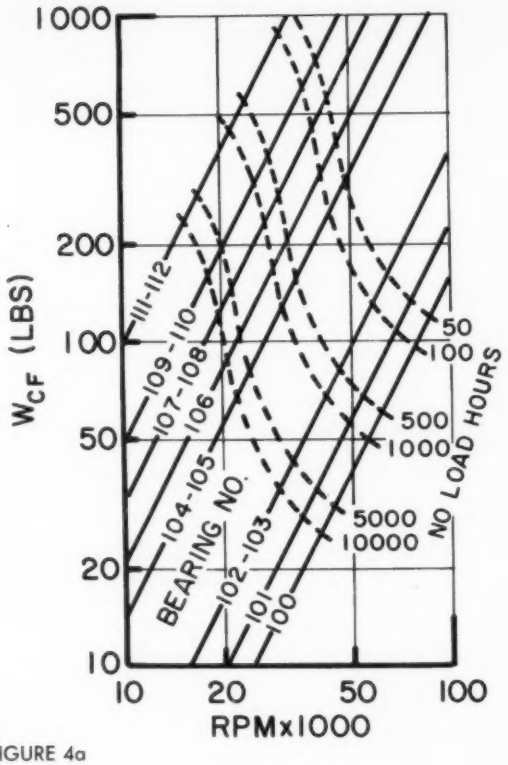


FIGURE 4a

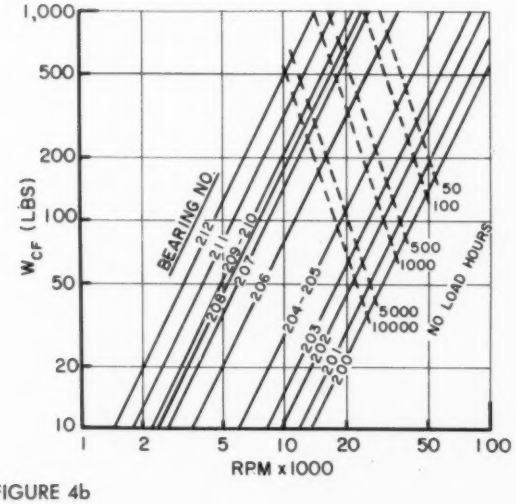


FIGURE 4b

FIGURE 4a, 4b, 4c, equivalent centrifugal load Wcf, as a function of speed for (a) 100-series, (b) 200-series, and (c) 300-series ball bearings. Dashed lines indicate constant bearing life at zero external load. ("By permission from *Bearing Design and Application* by Wilcock and Booser. Copyright, 1957. McGraw-Hill Book Company, Inc.")

operation down to −100°F. and also the highest temperatures up to 450°F. At the high-temperature end, the usefulness of synthetic materials, such as high-molecular-weight esters and silicone fluids, has been extended and made more effective by the use of unusual thickening agents.

It has been found that soap-thickened greases do not have the maximum heat stability needed for the extreme high temperature range and, therefore, many unusual materials have been investigated and are being used for such very high temperatures. These include organic modifications of clays, certain very stable dyestuffs and complex organic compounds such as the arylureas.[5]

Higher Speeds

Important advances have also been made in antifriction bearing lubrication at high speeds. In the past, a speed of 10,000 RPM was considered as high, however, RPM's of 50,000 to 150,000 are not unusual at this time in certain aircraft and machine tool applications[31, 7], mostly with oil mist lubrication.

Revolutions per minute is not the only measure of speed; one must consider the peripheral speed as being most important. A comparative measure of peripheral speed is the so-called DN Value (bearing bore in millimeters times speed in revolutions per minute) which give a speed factor. For instance, a No. 204 bearing (20 mm bore) at 10,000 RPM has a speed factor or DN Value of 200,000.

Experiments carried out at a major petroleum research center over the last several years have resulted

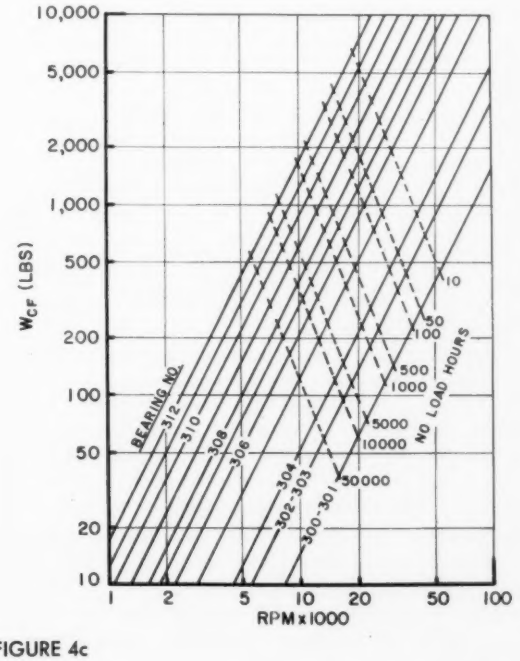


FIGURE 4c

in the development of greases which allow substantial bearing life for speeds up to 50,000 RPM for a No. 204 bearing; a DN Value of one million. This work has yielded valuable information on the types of greases which are suitable for such speeds and also some information on the types of ball-bearing design which are most appropriate.[8, 9]

Bearing life is usually defined as the time at which 10 per cent of the bearings have failed through fatigue. For a given bearing, doubling the speed halves the expected life of the bearing. Doubling the load reduces the life to one-eighth.

It has been emphasized recently that centrifugal load is a very important factor in ball-bearing life at very high speeds. Certain authorities[1] have arranged in graphical form a number of derived relations[10] on the effect of speed on equivalent radial load. Such information is presented in Figures 4a, 4b and 4c, and it may be seen that bearings become very heavily loaded from this effect when speeds of 30,000 to 50,000 RPM are achieved. This helps to explain why such a "scatter" of results is obtained on evaluating lubricants at such speeds. The bearings are loaded to such an extent that fatigue life is materially reduced. This factor is in addition to failures from cage wear and breakage.

Better Rust Protection

Another achievement in grease formulation has been the development of effective rust inhibitors. This has been concurrent with the development of suitable test techniques as will be discussed later. The development of rust-inhibited formulations has been particularly valuable for greases based on water-repellent soaps, such as calcium and/or lithium. Greases made from such soaps are extremely resistant to water washout, however unlike certain sodium soap greases,[11] they require additional fortification for optimum rust protection.

The need for a high degree of protection against rust is extremely important in applications where rolling-element bearings must stand for long periods of time in the presence of humid atmosphere. This may occur under adverse conditions of storage of prepacked bearings such as at tropical military depots, and it also may occur in wheel bearings during standing of vehicles or railway cars for extended periods.

Beyond the Horizon

Grease research is always reaching out and/or being pushed into new frontiers by military and industrial break-throughs. Perhaps the newest frontier at the present time is that of resistance to nuclear radiation. Such lubricants are of pronounced interest to the military and are becoming more important in industrial applications as atomic power plants go into operation.

In general, greases first soften on irradiation because of disintegration of the soap structure, and finally harden to porous and brittle substances owing to polymerization (combining of small molecules to form larger ones) and cross linking of the oil molecules. Performance life in bearings is reduced concurrent with reduction in oxidation resistance.

Such locations as remote fuel-handling devices, control rod drives, coolant pump bearings and accessory units will need greases with greater resistance to radiation as time goes on.[12] Current information indicates that such greases will probably contain an oily component high in aromatic content and that non-soap thickeners will probably be used.[13, 14]

Oil Lubrication

The advantages of grease were pointed out earlier. However, oil is more effective in carrying away heat. Oil also affords more positive feeding to loaded contact areas of bearings and furnishes a flushing action for any dirt, water or wear products. A corollary to this last fact is that the oil may be purified in a circulating sysem so that long periods of operation under adverse conditions may be achieved, whereas this would not be possible with grease in such applications as roller bearings on the dryer ends of paper mill machines.[15]

In many cases the requirements of other machine elements dictate the selection of type and viscosity of the lubricating oil used in the antifriction bearings. It is stated by current authorities[1] that "if other factors do not dictate the oil properties, the viscosity of the oil for a ball or roller bearing should be just high enough to insure satisfactory lubricating performance for the rolling elements and the separator. Higher viscosities will result in higher operating temperatures and higher power dissipation than necessary." These authors have made a composite of lubricant recommendations available in the recent literature with those of the bearing suppliers as a guide for selecting the proper oil viscosity for ball or roller bearings. This graph is reprinted as Figure 5.

Compositionwise, *mineral* oils are still quite adequate under most conditions for lubrication of antifriction bearings and are used extensively. However, for extreme conditions of low temperature and high temperature, or wide temperature range, *synthetic* oils are used. This is particularly true in modern turbine engines where the bearings are lubricated with synthetic oil of the so-called diester type. These bearings must be lubricated to permit military engine starting at −65°F. and to give satisfactory operation at temperatures of the order of 400-500°F. in some applications. In the future, the upper bearing operating temperature level is expected to increase. Accordingly, lubricant suppliers are continuing to devote considerable effort to the development of lubricants which will be superior to current fluids at elevated temperatures. A prime problem in this regard is the formation of bearing deposits resulting from this exposure of oil to high temperatures in the presence of air. The high temperature laboratory bearing tests now being developed should be of material assistance to those developing superior high temperature oils. Whether the superior high temperature products will possess the excellent low temperature properties of present oils is debatable;

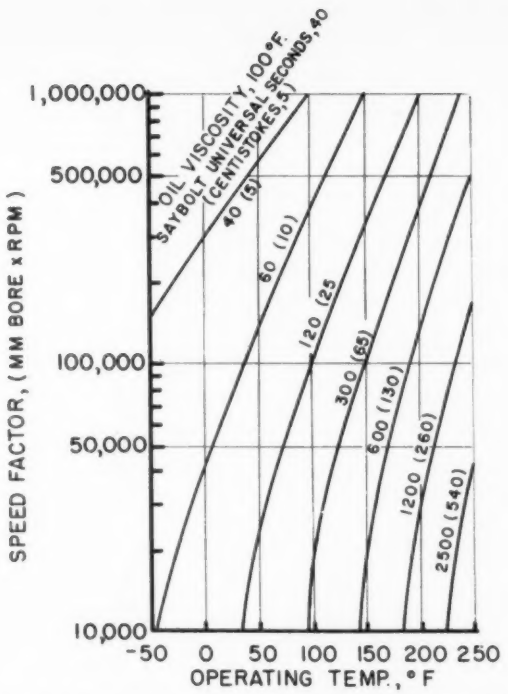


FIGURE 5, recommended oil viscosities for ball and roller bearings. ("By permission from *Bearing Design and Application* by Wilcock and Booser. Copyright, 1957. McGraw-Hill Book Company, Inc.")

it appears that if improvement is to be obtained at high temperatures some sacrifice in low temperature performance may be required. It is of interest to note that there is some evidence that certain mineral oils may be superior to synthetics at elevated temperatures. The surface deterioration of bearing working areas at elevated temperatures is also under investigation. The relative performance of different oils with respect to this factor is not at all well defined at present. Depending upon test conditions, synthetic oils may or may not be found superior to mineral oils.[16, 17, 32] Clearly, additional work will be required in this field to better understand the various ramifications involved.

Advances in Test Techniques

1. *Cooperative Developments*

The Coordinating Research Council has continued with its development of the 10,000 RPM spindle test for greases which uses a No. 204 test bearing. This test is now called for in military specifications at temperatures up to 450°F. (MIL-G-25013A) and precision is quite good even at the highest temperature. At 450°F, and above it is necessary to use special high alloy tool steel bearings to avoid dimensional changes. The CRC is now continuing its work at the 600-700°F. level in view of continuing demands from the Military that evaluation methods at such temperatures be made available.

In the field of fretting corrosion, considerable advance has been made in developing a suitable instrument for determining the effect of lubricating greases in minimizing this form of wear. The August, 1955 issue of *Lubrication* was devoted to this subject and contains on page 93 a photograph of the Sikorsky apparatus for oscillating radially loaded bearings, such that the effect of lubricants on their fretting corrosion tendencies may be determined. A very recent publication brings this work up to date.[19]

A much needed development has been the final publication of a technique for evaluating the rust-resistant properties of lubricating greases. This work is the culmination of a number of years of cooperative investigation along these lines and has resulted in a simple bearing protection test technique. In this test a small tapered roller bearing is packed with the grease to be investigated and placed in a jar in the presence of a small amount of free water. The jar is then closed and the assembly kept for fourteen days at 77°F. At the end of this time the bearing is cleaned and examined for rusting. This test is described in Military Specification MIL-G-3278A, "Grease, Aircraft and Instrument." Correlation was obtained between the bearing protection test and two full-scale field tests in different parts of the U.S.A. on fleets of aircraft in which the test greases were placed in the wheel bearings of the aircraft.[29]

The ASTM* has standardized the automotive wheel bearing performance test originally developed by the CRC and this test has been in military specifications such as MIL-G-2108 for some years. It measures the leakage tendencies of greases; however, being a short-time (6-hour) test it does not evaluate the lubricating abilities of the grease. Figure 6 shows a photograph of this test unit. The necessity of full-scale field tests as a proof of automotive wheel bearing service is well proven by a comprehensive study reported in 1954.[20]

Compatibility of lubricating greases has received considerable attention during recent years. It has been found that mixtures of certain greases may show softening and high leakage under certain conditions from physical structure changes. It is also possible for chemical interactions to take place. For instance, when a grease containing high free alkali content is mixed with an ester-type synthetic grease, saponification of the ester may occur resulting in an unsatisfactory lubricating mixture. While various short-time tests have been proposed as suitable for testing compatibility of grease mixtures, the only safe way is to run such blends in antifriction bearing machines under the same type of conditions which will be experienced in the field. Such tests must be carried out for considerable periods of time, as short-time tests may not predict latent incompatibility.

The ASTM has considered this question and Tech-

* "American Society for Testing Materials"

FIGURE 6, ASTM wheel bearing tester. Apparatus, which employs a 1942 Ford front wheel hub, is driven at a speed equivalent to 40 miles per hour. Test bearing assembly is enclosed in insulated hood so tests can be made at elevated temperatures. Special ring is used in place of regular grease retainer, to catch any grease which leaks from the inner end of the hub.

nical Committee G of ASTM Committee D-2 has issued the following statement:

"Statement on Compatibility Testing of Lubricating Greases

Compatibility of lubricating greases implies compatibility in service. Owing to the complexity of service problems, there is no single test which can be used to satisfactorily evaluate compatibility in general.

Present ASTM methods, such as those for dropping point, worked penetration, and leakage tendencies of automotive wheel bearing greases, may be used to test individual greases. Results obtained on such mixtures, as compared to results on the unmixed component greases, are indicative of the compatibility of the mixtures. However, simple bench tests such as these must be correlated with a particular set of service conditions before a valid estimate of compatibility in such service can be achieved."

As an example of a rigorous mechanical test for compatibility, the Association of American Railroads (AAR) has issued Specification No. M-917-56 where greases submitted for qualification must be run with mixtures of approved products in an eight-week simulated service test. A four-axle tester with two roller bearing assemblies (6x11 boxes) per shaft is used. The shafts turn at 640 RPM which is equivalent to 63 MPH for a 33-inch freight wheel. The tests run for eight weeks with periodic shut-downs. Fan blades on the shafts provide cooling to simulate the windage of road operation. A 600-lb. vertical load is imposed on each bearing.

The development of suitable greases for railroad axlebox roller bearings has been an outstanding development of the past decade. Reduced maintenance has meant lower labor costs. Tests have shown that freight car grease-lubricated bearings can operate for at least three years without relubrication.[21] This whole picture is well summarized in a very recent comprehensive paper by a representative of a large roller bearing manufacturer.[21]

2. *Individual Developments*

Some years ago a large petroleum research laboratory developed a highly versatile Railroad Journal Bearing Tester which has been in constant and useful operation since its installation. Figure 7 shows this apparatus which tests two full-scale roller bearing assemblies at one time. Heavy vertical and thrust loads are imposed, together with superimposed shock loading, all activated hydraulically. Lateral play is provided for as in actual service, and friction measurements may be made at the start of and during a run. This machine has aroused much interest in domestic and European railroad circles and similar equipment has been constructed by the AAR.

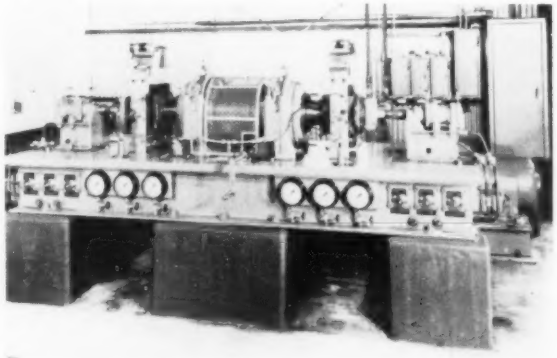


FIGURE 7, seven-ton, full-scale Railroad Journal bearing test machine developed by a prominent petroleum research laboratory showing two actual 5½x10 inch journal boxes assembled with vertical loading yokes and axial load cylinders.

A large manufacturer of electrical equipment has been running for a number of years an interchangeable cartridge high-temperature ball-bearing grease tester which was described in detail at the ASTM Symposium on Functional Tests for Ball Bearing Greases in 1948.[2] Tests are run up to 10,000 hours at 212°F. ambient temperature. This test utilizes a No. 306 bearing with a 160 pound radial load and 40 to 50 pounds thrust load and runs at 3600 RPM. It is considered to give a good simulation of electric motor bearing operation, as far as grease life goes, under laboratory conditions. Figure 8 shows a sectional view of this bearing tester.

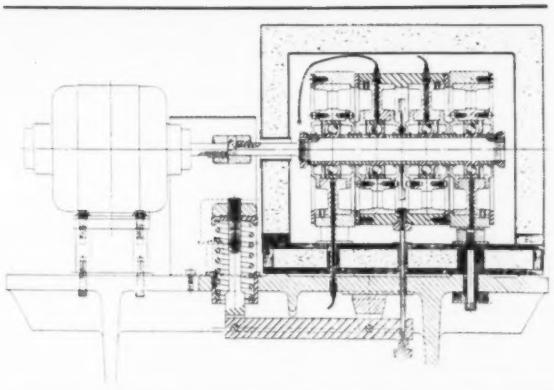


FIGURE 8, sectional view of G.E. four-bearing interchangeable cartridge high-temperature ball bearing grease tester. (Reprinted from article *"Grease—An Oil Storehouse for Bearings"* by D. F. Wilcock and M. Anderson, *Symposium on Functional Tests for Ball Bearing Greases*, STP-84, ASTM[2]).

A large manufacturer of rolling-element bearings has developed valuable correlations from temperature-load-speed studies on ball bearing life on test rigs of their own design.[22]

A recent publication describes the scope of evaluation and testing imposed by a major petroleum company on the various greases developed.[23]

For testing the performance of roller bearing greases under heavy loads the SKF roller bearing test machine continues to be of particular value.[24] This apparatus tests 5½ inch OD cylindrical roller bearings under 4240 pounds per bearing radial load and a usual speed of 2100 RPM. By means of cartridge heaters under the test bearings it is possible to run at elevated bearing temperatures. The value of this machine in studying the performance of different grease types, as well as further studies with the vibrating wheel bearing tester and the torque-breakdown machine are described in a paper published in 1955.[24]

In Europe the SKF R2F Test is widely used, in which spherical roller bearings of 60 mm bore are used as the test bearings. Various conditions of speed and temperature are imposed on the lubricating greases to be evaluated. This type of bearing, which has barrel rollers and a curved outer raceway, possesses high load-carrying capacity. Because of the greater degree of contact (osculation) between roller and outer raceway, this design constitutes a severe test for lubricating greases particularly at increased speeds.

There has been considerable test development in the field of traction-motor-armature roller bearings for railroad use. The use of sealed bearings with the initial bearing lubricant charge lasting between overhauls with no relubrication is now an accepted procedure and widely used. Periods of 300,000 to 500,000 miles

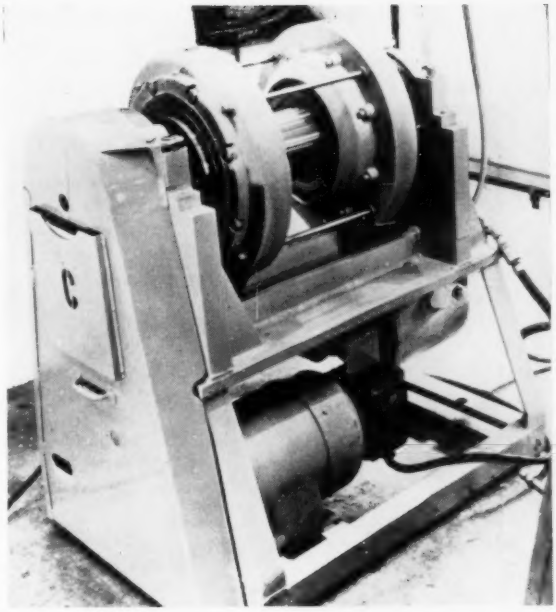


FIGURE 9, EMD traction motor armature bearing tester. (Utilizes 130 mm bore test bearings; representative test conditions are 500-hour duration, 2500 RPM, room ambient temperature and 740-lbs. load per bearing. Superimposed vibration is 800 CPM.)

between relubrications of such bearings are now being achieved in railroad service. Whereas formerly flange-riding-cage roller bearings were used, the trend is now to roller-riding-cage roller bearings. Figure 9 shows a picture of the EMD design of traction motor armature bearing tester.

Miniaturization, radiated heat from jet engines and aerodynamic heating at supersonic speeds are three of the important factors in the military picture which have pushed grease operating temperature requirements

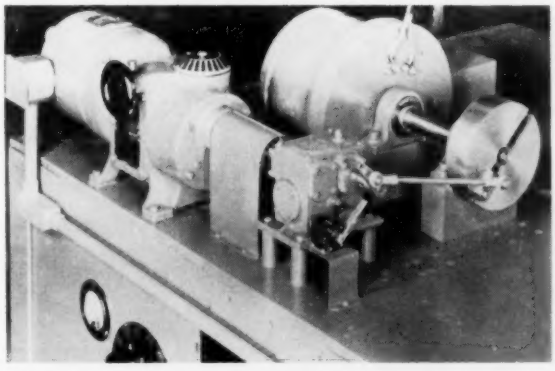
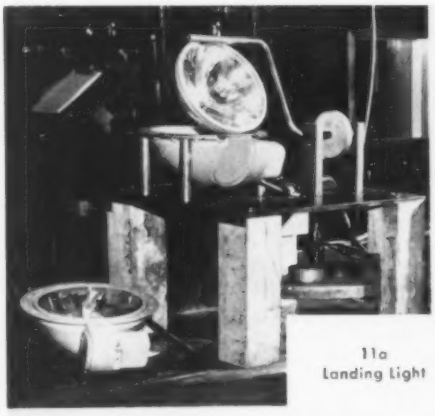


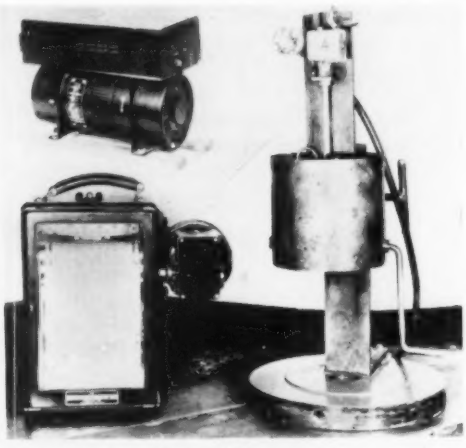
FIGURE 10, high temperature oscillating control bearing tester. Apparatus is used to determine the life of a grease in aircraft control-type bearings up to 550° F. An automatic device shuts down the tester when the torque exceeds one foot-pound.

to 450°F. and higher. As early as 1949 the USAF* asked a subpanel of the Coordinating Research Council to screen existing aircraft control bearings and lubricants for life at 500°F. This work led to the development of an oscillating control bearing tester in which tests were run up to 550°F. under conditions of load, degree of oscillation, and speed representative of a jet

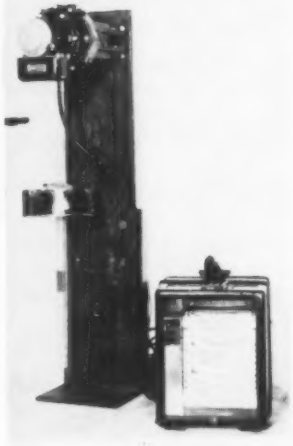
* United States Air Force



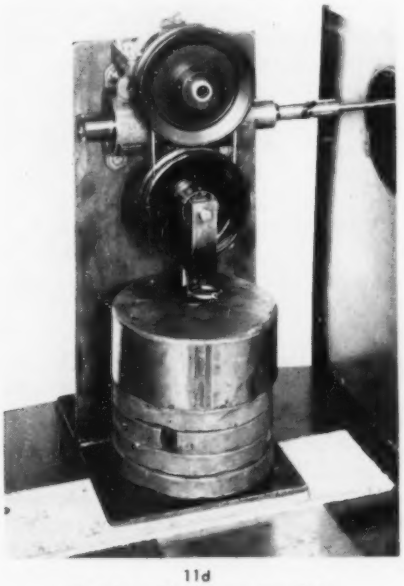
11a
Landing Light



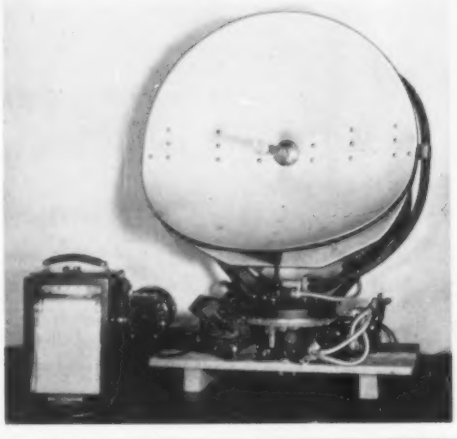
11b
Actuator Assembly
Shutter-vane Intercooler with 400-cycle Inverter



11c
Actuator Assembly
Bomb-Bay Door



11d
Gear Assembly, Elevator Flap Tab



11e — Antenna Assembly

FIGURE 11, composite view of five pieces of aircraft accessory equipment tested at temperatures down to —100°F.

fighter at that time. When conventional KP-16A bearings were fitted with heat-resistant seals it was possible to get 20 to 80 hours life at 550°F. with a non-soap, solid-thickened/silicone fluid grease and up to 248 hours at 500°F. with this grease.[25] Figure 10 shows a picture of this apparatus.

The field of extreme low temperatures has not been neglected. In one detailed study, an intensive program[26] has been carried out to note the degree of correlation of torques measured by simple laboratory bench rigs with the results obtained on full-scale aircraft accessories at temperatures down to −100°F. Figure 11 shows a combined view of the various pieces of accessory units which were evaluated in this study and Figure 12 (as shown on cover illustration) pictures a retractable landing light with the auxiliary equipment necessary to run these tests.

The conclusions from this work were that there were more variations between units of supposedly identical construction than there were between greases meeting the same military specification which in this case was MIL-G-3278A, "Grease Aircraft and Instrument." A certain accessory which was overpowered, operated at −100°F. even with a grease which was designed only for −40°F. operation (the criterion being one revolution of a No. 204 bearing at 5 seconds or less at 2,000 gram-centimeters torque). A unit of another accessory was under-powered and would not operate at −65°F. even with the grease designed to work at −100°F. as judged by the 2,000 gram-centimeter criterion. Therefore, apparently large numerical differences detected by a sensitive laboratory bench test may have no significance for actual mechanisms where a number of bearings, gear trains, etc., are involved, and where the power available to cause operation of the unit is a very important factor.

Lubricating grease performance in the presence of water is an involved phenomenon, including resistance to washout, lubrication under dynamic conditions and rust protection under both dynamic and static conditions. A recent study has been made of these factors, and a test technique developed to separate and measure the various effects.[27]

Advances in Relubrication

1. *Greases*

The foregoing sections have described the great advances in sealed and cartridge-type bearings, where one fill of grease lasts for the life of the part or to a major overhaul. Yet there are many applications such as in the metal industries and in industrial machine lubrication, where periodic relubrication—"the right amount of the right grease at the right time"—is a must.

The August 1957 issue of *Lubrication* gives a comprehensive and up-to-date picture of automatic grease dispensing equipment and pertinent information on flow properties of greases and so forms a valuable supplement to the issue at hand.[30]

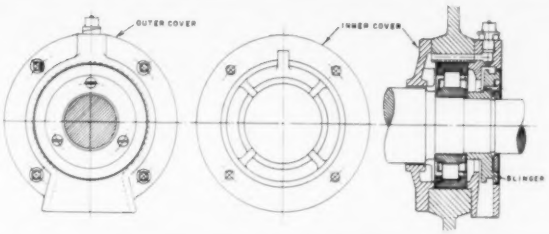


FIGURE 13, grease valve in electric motor with end frames (reprinted from SKF brochure TSP 5243[28]). Note design of bearing housing covers which incorporate radial webs to lead new grease into the bearing.

A further development which has taken firm hold in Europe during recent years is that of the so-called "grease valve" which expedites the relubrication of running bearings on individual pieces of equipment such as large electric motors, centrifugal pumps, and water turbine "plummer" (pillow) blocks.[28] This device is reported to be particularly suitable for the breaking-in of new spherical roller bearings where flooded grease lubrication is recommended during the first hours of operation. The grease valve is essentially a rotating slinger which directs grease purged through the bearing into a venting passageway so that excess grease will not pile up in the bearing and cause overheating, churning and grease breakdown.

Figure 13 shows a drawing of a grease valve arranged for electric motor bearing relubrication. Figure 14 shows how the valve causes a rapid drop in temperature following successive relubrication periods as compared to operation without the valve.

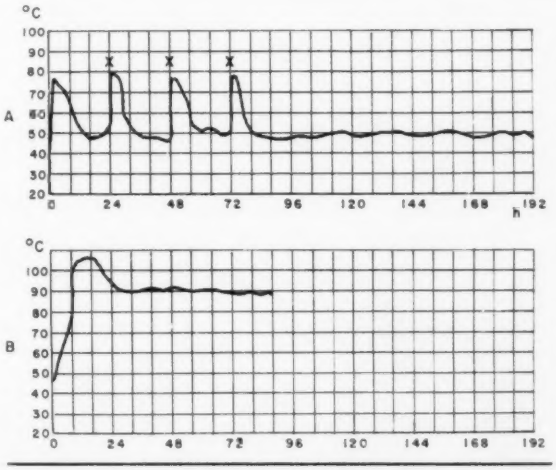


FIGURE 14, temperature graphs obtained during relubrication tests. (a) is an SKF roller bearing 22328M running at 1100 RPM in conjunction with grease valve. (x) is relubrication point. (b) is same type of roller bearing without grease valve. (Reprinted from SKF brochure TSP 5243[28]).

SYSTEMATIC ROLLING-BEARING TROUBLE-SHOOTING CHART

By permission from *Bearing Design and Application* by Wilcock & Booser. Copyright, 1957. McGraw-Hill Book Company, Inc.

Cause	*Remedy*
1. Overheated Bearing:	
a. Inadequate lubrication	Change to proper grease or oil. Adjust oil-cup height, maintain oil level at center of lowest ball or roller. Fill grease housing one-half to two-thirds full. Clean oil holes, filters, and vents. Use a fresh lubricant.
b. Excessive lubricant churning	Use lower-viscosity oil, lower oil level to center of bottom ball or roller, fill grease housing only half full, use oil mist.
c. Inadequate internal clearance	Use bearing of greater looseness, allow for differential thermal expansion, reduce interference of shaft and housing fits, correct any housing out of roundness or warping.
d. High seal friction	Stretch felt or use reduced spring tension with leather or composition seals, lubricate seals, switch from rubbing seal to low-clearance shield.
e. Excessive preloading	Use gaskets or shims to relieve axial preload with opposed pair or with two held bearings on a shaft subjected to thermal expansion. Change design to use only one held bearing.
f. Spinning outer ring	Use closer housing fit, use steel insert in soft aluminum housing, use garter spring or rubber holding ring.
g. Misalignment	Correct alignment by shimming pillow blocks, housings, or machines to get shafts and bearings in line. Check for misalignment of bearing seats and shaft and housing shoulders.
2. Noisy Bearing, Vibration:	
a. Wrong type of grease or oil	Check recommendations of lubricant supplier. A higher-viscosity oil or a better-feeding grease with a higher-viscosity oil may help.
b. Insufficient lubrication	(See 1a)
c. Defective bearing	Check for brinelling, fatigue, wear, groove wobble, poor cage. Replace bearing.
d. Dirt	Clean bearing housing, replace worn seals, improve seal arrangement, eliminate source of dirt.
e. Corrosion	Improve sealing to keep out corrosive elements, use corrosion-resisting lubricant.
f. Too great internal clearance	Change to bearing with smaller clearance.
g. Unbalance	Balance rotor.
h. Misalignment	Align (see 1g).
i. Too loose shaft or housing fit	Build up shaft or bore with chrome plate or metallize and regrind.
j. Improper Mounting	Correct dirty or off-square shaft and housing shoulders and seats. Avoid brinelling caused by pounding on bearing.
k. False brinelling	Use vibration mounts for machine to isolate from platform during idle periods.
l. Seal rub	Check for metal bearing seal or shield rubbing on shaft, shoulder, or housing.
3. Loss of Lubricant:	
a. Oil leakage through seal	Adjust oil level to center of lowest ball or roller, replace seal, use double-seal arrangement with drain between, eliminate any unfavorable air flow by proper baffles and balancing channels.
b. Leakage at housing split	Use thin layer of gasket cement, replace housing.
c. Grease leakage	Pack housing only one-half to two-thirds full, use channeling-type grease, eliminate any pressure causing air flow through bearing, keep solvents or water from entering and softening grease, use new or improved seals.
d. Dry, caked residue	Use silicone or other high-temperature grease, use oxidation-inhibited or synthetic oil or grease, cool oil in external cooler, cool bearing housing, increase oil flow to promote cooling.
4. Loose Bearing:	
a. Shaft diameter too small	Turn down shaft, chrome-plate or metallize and regrind to give proper fit. Retighten adapter to get firm grip on shaft.
b. Housing bore too large	Build up bore with chrome plate or metallize and regrind, bore out housing and press in sleeve to give proper bearing fit (a slip fit on OD is usually desirable to allow for differential axial thermal expansion of a shaft between two bearings).
5. Hard Turning of Shaft:	
a. Excessive bearing preload	Use less interference fit on shaft or in housing, select bearing with greater internal clearance where heat conduction expands shaft and inner bearing ring. Relieve axial preloading by housing shims with either two opposed bearings or two "held" bearings on one shaft.
b. Heavy seal rub	Stretch felt seals to reduce their friction, use reduced spring tension on leather or composition seals, scrape out ID of rubber seals, use a shield with clearance on the shaft.
c. Dirt	Clean housing and use fresh lubricant (see 2d).
d. Corrosion	(See 2e)
e. Lack of lubrication	Raise oil level to center of lowest ball or roller, grease pack housing half full. Eliminate possibility for loss of lubricant by leakage.
f. Incorrect lubricant	Use softer grease or thinner oil.
g. Bearing pinching or cocking	Scrape housing bore to relieve pinching. Replace or remachine warped housings, check bearing seats as source of cocking.

2. *Oils*

A companion article to the August 1957 issue is that of November, 1957 on Central Air-Borne Lubrication Systems which describes the unconventional but very important systems for application of lubricating fluids as a spray or more finely atomized mist.

Summary

It is difficult to overemphasize the importance of rolling-element bearings to our economy. The petroleum industry is proud to have been a companion in the development of present bearing/lubricant systems upon which so much of industry and our defense effort depend.

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About the Author

R. S. Barnett *received a ScB degree in chemistry from Southwestern La. Inst. in* 1929. *He then became a teaching Fellow at N.Y.U. receiving the degree of ScM in organic chem. from that university in* 1931. *He then joined the Texas Co. at Texaco Research center and has been assigned there ever since. He has been concerned largely with lubricating grease applications, research and analysis with considerable field work and supervisory experience. He has lectured before three ASLE sections, and is the author or oc-author of a number of articles on lubricating grease fretting corrosion and chemical analysis in NLGI, ASLE, ACS, ASTM and aviation journals.*

Two Tons of Grease

The Design and Use of a Large Volume Grease Container

Presented at the NLGI 26th annual meeting in Chicago, October, 1958

By
J. W. Waite
Inland Steel Company

Introduction

An expanding economy has required an ever increasing quantity of steel. This demand has been met not only by the installation of more facilities, but also by enlarging the capacity of each new piece of equipment. This growth in size has been accompanied by a trend toward automation resulting in a greater complexity of machine members.

Assured lubrication is the factor that has made many of these designs workable. Increased speeds, temperatures, and bearing loads have precluded a program that permits "hit or miss" lubrication. Circulating oil systems have been employed to give positive protection to essential bearings. However, there are many points requiring a lubricant where either cost or design limitation has prohibited a circulating system. These are best serviced by grease application.

Several systems have been developed that will supply a measured amount of grease at predetermined time intervals, thus providing the same assured lubrication that is possible with a circulating oil system. There are, however, certain disadvantages associated with the use of grease. Some of these are: cost of handling and application; space requirements for the storage of adequate inventories; packaging costs; and the possibility of contamination. It is believed that in a limited number of applications, bulk handling techniques can lessen these disadvantages.

To provide ideal lubrication for a machine, a department, or for an entire plant, is the aim of every lubrication engineer. One of the outstanding obstacles to overcome is human error and indifference. Any tool or practice that will aid in reducing blunders is a worthwhile investment. If the device also reduces operating costs, it becomes doubly attractive. The possibility of gaining these advantages through bulk grease handling should be investigated.

Any departure from the conventional requires a careful evaluation of all the factors involved. What benefits could be gained by handling grease in larger volumes? What would be the disadvantages and limitations of the proposed change? What equipment would be best suited for gaining the desired results? The answers to these questions vary depending on the particular plant and application visualized. The factors that determined the initial installation will be discussed.

Advantages of Bulk Grease Handling

In a suitable application the advantages of bulk grease handling are primarily twofold—improved lubrication techniques and reduced operating costs.

Many of the oil companies have prepared publications to aid their customers in obtaining maximum benefits through the use of their products. Usually, a section has been devoted to the storing and handling of lubricants. Without exception, the importance of avoiding contamination is stressed. Extremes in ambient temperature and excessive humidity of the storage area, together with prolonged storage time, is described as being detrimental to grease. Repeated handling of packages with the possibility of mechanical damage to the container is to be avoided.

Handling and warehousing procedures vary from plant to plant, but, in general, a common problem exists in all large plants. Products are received and stocked in a large central warehouse. Materials are then dispersed to the various departments as required. Each department maintains a reserve from which maintenance personnel can draw stock. Empty containers are then returned to a central area for disposal. Handling, warehousing, and transportation charges within the plant may exceed three dollars per drum of grease used.

Although the contents of a drum can be removed completely with little effort, a careful survey established that drums were being returned with an average of fifteen pounds of product retained in each. This represents a loss of two and one-half dollars.

The most significant savings can be made in eliminating the conventional packaging cost.

There are other savings to which it would be difficult to assign a monetary value. Safety, housekeeping, and morale would be improved—these are intangible but important. Although improved lubrication techniques have been mentioned, it should be emphasized that a direct savings in maintenance cost will follow when the correct, clean lubricant is applied at the proper interval. A bulk container filled with a refinery fresh product; delivered to the point of use; and connected into the system precludes the possibility of contamination, improves storage conditions, and reduces operating costs.

Disadvantages of Bulk Handling of Grease

An innovation in design or handling methods is made to gain certain desired results, therefore, the advantages are evident. The important consideration is whether or not the expected results outweigh any adverse conditions that may be incurred.

One of the first questions is that of cost. Can the cost of equipment and installation be justified? It is expected that the direct savings will pay for equipment and installation in the application being considered, in less than five years. With no equipment available for the type of installation desired, and with very little practical data to work with, undoubtedly an excess of capacity in pumps and lines was installed. Refinements in design of future installations could effect a lower cost.

A second disadvantage is the cost of transporting the empty container. With the container used in this system, a source of supply must be available in the immediate area; or the cost of transportation could be greater than the expected savings.

A third disadvantage is the one that is normally associated with any deviation from the established pattern of procurement. A greater degree of coordination is required between supplier and consumer. Filling schedules must be arranged to the mutual benefit of both. A

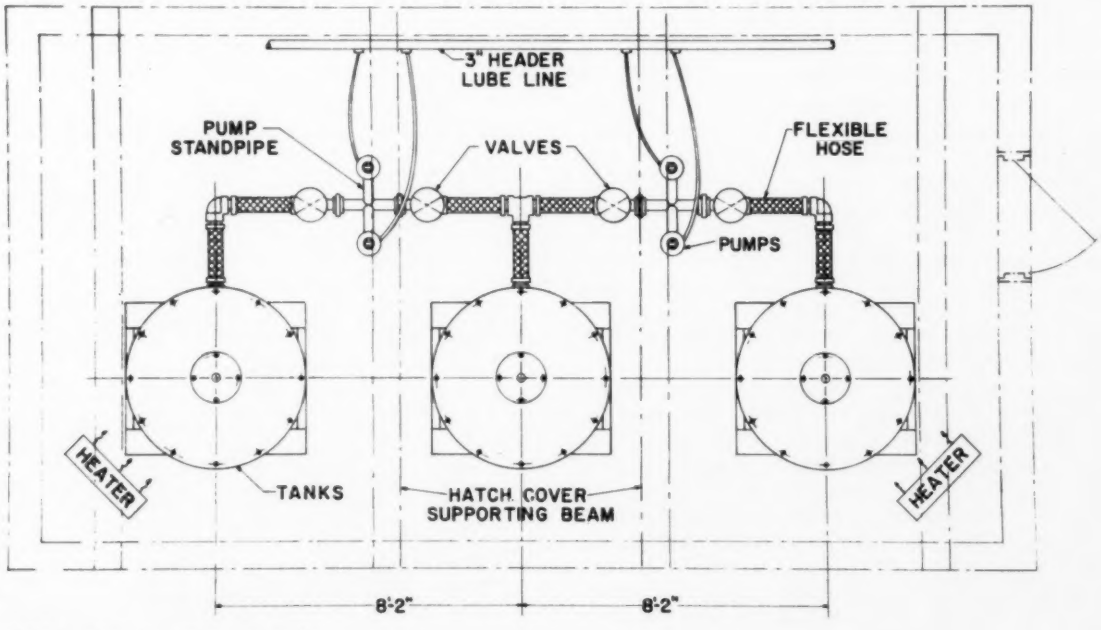

FIGURE 1, plan view of grease tanks

problem of billing also arises. The container must be weighed before and after filling so that proper charges can be made. There is also the problem of maintaining sufficient inventories of product to take care of any emergencies.

Application of Bulk Grease Handling

Having considered the advantages and disadvantages of bulk grease handling, the next step is to determine the limits of its application. A "barrel to bearing" system is the ideal equipment for the consumer of moderate amounts of grease. There are many industrial processes that use large quantities of grease in a compact area. If a multi-purpose grease can be selected to fulfill all greasing requirements, a bulk supplied grease system should be considered. A description of the facility where the initial installation was made will illustrate a practical application.

A universal slabbing mill was designed to require grease lubrication of over on thousand points. Nine automatic and five hand operated systems were required to provide adequate lubrication and to permit flexibility of timing cycles. The total distance from the ingot receiving table to the slab pilers is 695 feet.

The problem of location, service, and protection of the automatic systems was presented. The prospect of a number of buildings on the mill floor to house these systems was not attractive. A central grease house with a header extending the length of the mill building was suggested. Supply lines from the header could be installed for each system, thus, permitting them to be located in the basement where desired. The requirements of storage space for full and empty containers, together with frequent changes of drums, and the labor required to keep such an area clean and safe, combined to make innovations in grease handling acceptable.

Description of Bulk Grease System

The elements of a bulk grease system are: (a) lubrication requirements of sufficient volume to make the installation economically sound (b) means of supplying the individual systems, that is, a header line (c) suitable large volume containers.

Referring to Figure 1: Three tanks are arranged so that grease may be pumped to the header by either of the two pumping stations. Flexible hose compensates for some misalignment and permits interchanging the tanks. For filling, the tanks are taken from the building through the removable hatch covers.

Figure 2 illustrates the pumping arrangement used. Standard 22 to 1 ratio air driven barrel pumps are used. The pumps are used in tandem to provide rapid filling of the reservoirs. Several features of the air driven pump make them ideally suited for this application. Air pressure may be regulated to give the desired pressure in the header line. Since the pump will stall when the maximum pressure in the header is produced (consistent with the regulated air pressure) and the header is designed to withstand the maximum pressure; there is no need for pressure relief valves, pressure switches, or other special control devices. The reservoirs are located various distances from the pumps. So the feature of variable pump delivery, dependent on line resistance, is desirable. In the event of pump failure, a replacement may be substituted quickly and with minimum effort.

The grease header is schedule 160 pipe, three inches in diameter, and four hundred and eight feet long. It is steam traced using three-eights inch steel tubing with spacer blocks to prevent the steam line from contacting the header. There is a one inch diameter pipe supply line to each dispensing unit with a high pressure shut off valve before the reservoir.

Design of a Bulk Grease Container

Figure 3 is a cross section of the bulk grease container designed by the author which best suits the requirements of the installation discussed. It illustrates features of this design.

The rolled steel shell is of three-eighths inch plate reinforced with steel ribs. This should provide the ruggedness necessary in steel mill equipment to give long and trouble free life. The cover and bottom is of three-quarters inch plate. The tank is mounted vertically on fourteen inch wide flange beams to give clearance for the valve and piping. This entire assembly is welded together to form a single unit, with the exception of the cover, which is bolted in place.

The follower plate is a single unit constructed to be bouyant. The pipe, that is used for a guide and indicator, is removable for shipping the filled container. Special attention is called to the inflatable seal. This makes it possible to employ atmospheric pressure to provide positive prime to the pumps. The seal also wipes the walls clean during each cycle, insuring a fill uncontaminated by old grease.

A single line and valve from the center of the bottom of the container provides for both filling and

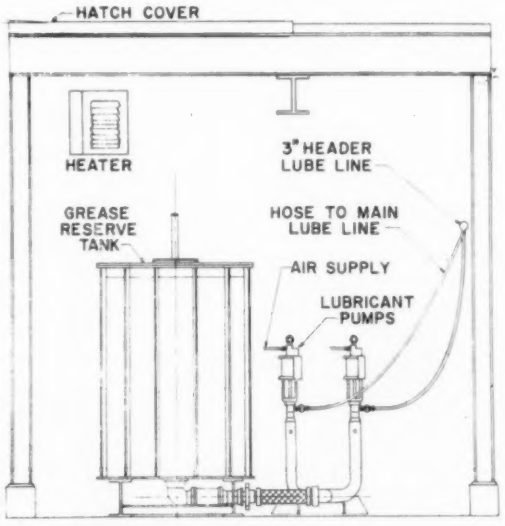

FIGURE 2, Side view of grease tank

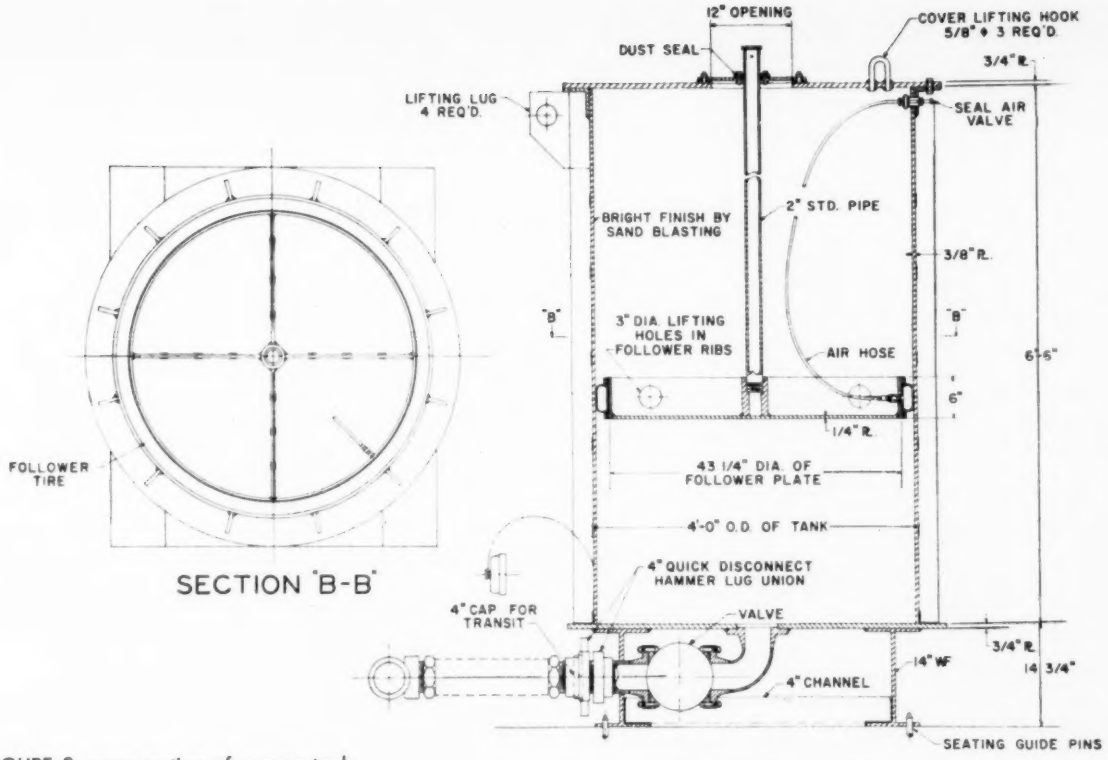

FIGURE 3, cross section of grease tank

emptying. This is of importance, for it permits the tank to be pressure filled without entraining air in the grease. Air in the pump stand pipes could cause the pumps to loose suction.

The volume of the tank is sufficient to hold two tons of grease.

Summary

An expanding economy has demanded machines of increasing size and complexity. To insure uninterrupted performance of this equipment, extensive automatic lubrication devices have been installed. Increased speeds, temperatures, and bearing loads have placed more exacting demands on the lubricants.

Any device or technique that will improve lubrication practice, streamline handling methods, or reduce operating costs, merits investigation. One possible way of accomplishing these three objectives is through the installation of a system for bulk handling of grease. However, there are certain disadvantages of such a system, namely: the initial cost of equipment and installation is high; additional cost is incurred in transporting the empty container and a greater degree of coordination between supplier and consumer is required.

A study of bulk handling methods resulted in the design and installation of this equipment in a blooming mill facility. Operation of the completed system began in September of this year. Although it would be premature to report success of bulk grease handling methods, developments in this field will be of importance in the near future. Both manufacturers and consumers of grease should give careful consideration to the potential of this new handling method. ■

About the Author

J. W. Waite *is a lubrication engineer with Inland Steel company. A machinist by trade; a registered mechanical engineer by profession, he has had a wide variety of experience with Inland over the past nineteen years including machine tool operation, diesel maintenance, construction work and mechanical maintenance supervision in the tin mill. He was graduated from Rose Polytechnic Institute with a BS degree in mechanical engineering in* 1950 *and was registered as professional engineer in the state of Indiana in* 1957. *With his employment as lubrication engineer in* 1957 *Mr. Waite became a member of ASLE and has since been active in that organization.*

Index to NLGI SPOKESMAN, Vol. XXII

April 1958-March, 1959

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INDEX BY TITLES

Ball and Roller Bearing Lubrication, R. S. Barnett, 12, XXII, March, 1959

CRC Laboratory Technique for Determining Rust-Preventive Properties of Lubricating Greases, E. W. Adams, 4, XXII, July, 1958

Current and Future Military Grease Requirements, R. J. Horwath, 10, XXII, January, 1959

Definitions of Terms Relating to the Lubricating Grease Industry, Part II, W. J. Ewbank, 8, XXII, November, 1958

Development of an Extreme High Temperature Grease, J. W. Armstrong, H. A. Woods, 1, XXII, April, 1958

Development of Extreme Pressure Greases, R. K. Smith, 9, XXII, December, 1958

Discussion of "The Ordnance Corps Looks Into Grease Bleeding," R. H. Leet, A. C. Borg, 2, XXII, May, 1958

Field Testing of Automotive Chassis Greases, C. L. Knapp and J. Panzer, XXII, 7, October, 1958

Flow Properties of Lubricating Oils Under Pressure, S. J. Hahn, H. Eyring, I. Higuchi, T. Ree, 3, XXII, June, 1958

Future Lubricating Grease Requirements in the Steel and Underground Coal Mining Industries, J. C. Van Gundy, 11, XXII, February, 1959

Grease Bleeding—A Factor in Ball Bearing Performance, A. E. Baker, 6, XXII, September, 1958

Lubricating Greases: A Summary of Facts and Opinions, American Lithium Institute, 1, XXII, April, 1958

Market Potential for Automotive Grease, W. M. Drout, Jr., N. L. Jenkins, 9, XXII, December, 1958

The Mechanisms of Dispersion, K. H. Birkett, 11, XXII, February, 1959

The Mixing Efficiency of Grease Kettles, A. Beerbower, E. O. Forster, J. J. Kolfenbach, H. G. Vesterdal, XXII, 5, August, 1958

Modern Methods of Lubricant Application, E. J. Gesdorf, 4, XXII, July, 1958

Needed—New Driver Attitudes, H. A. Mayor, Jr., 9, XXII, December, 1958

A New Equation for Calculating Flow of Lubricating Greases, D. W. Criddle, 8, XXII, November, 1958

The Ordnance Corps Looks Into Grease Bleeding, S. F. Calhoun, 2, XXII, May, 1958

Packaging—An Essential Service, A. D. Murphy, 3, XXII, June, 1958

A Preformed Organic Thickener for Lubricating Greases, W. L. Hayne, Jr., J. E. Kline, T. P. Traise, 12, XXII, March, 1959

Pyrogenic Silica-Thickened Greases, Peter B. Marsden, XXII, 5, August, 1958

Question and Answer Session—NLGI Panel Discussion Symposium on Fundamental Research Aspects of Bleeding of Lubricating Greases, XXII, 7, October, 1958

A Rapid Method of Analysis and Evaluation of Lubricating Grease, F. E. Chamberlin, C. F. Carter, J. L. Dreher, 10, XXII, January, 1959

Recommended Practices for Lubricating Automotive Front Wheel Bearings, 1, XXII, April, 1958

Scientific Detection in Grease Lubrication Problems, R. J. Ronan and M. C. McLaren, 10, XXII, January, 1959

Selling the Magic Film Promotionally, H. A. Mayor, Jr., Jack Hodges, Oliver Elliott, 2, XXII, May, 1958

Sensory Examination of Lubricating Greases, Albert S. Orr, XXII, 5, August, 1958

Social Maturity for the Corporation, R. P. Dinsmore, 8, XXII, November, 1958

Some Practical Benefits of Mechanical Dispersion, J. J. Dickason, 11, XXII, February, 1959

The Studebaker-Packard Twin Traction Differential —Its Problems and Limitations, O. K. Butzbach, P. Izdepski, 3, XXII, June, 1958

Summary of Research by ASTM Technical Committee G-IV on Bleeding of Lubricating Greases, XXII, 7, October, 1958

Tensive Stresses on Lubricating Greases Reduce Bleeding, Dean W. Criddle, Jay Cortes, Jr., 6, XXII, September, 1958

Two Tons of Grease, J. W. Waite, 12, XXII, March, 1959

Your Drum Can Make More Trips, Allen A. Armitage, 1, XXII, April, 1958

INDEX BY CATEGORY

AUTOMOBILES

DIFFERENTIALS

The Studebaker-Packard Twin Traction Differential—Its Problems and Limitations, O. K. Butzbach, P. Izdepski, 3, XXII, June, 1958

DEFINITIONS OF TERMS

Definition of Terms Relating to the Lubricating Grease Industry, Part II, W. J. Ewbank, 8, XXII, November, 1958

GENERAL

Lubricating Greases: A Summary of Facts and Opinions, American Lithium Institute, 1, XXII, April, 1958

LUBRICATING GREASE

ANALYSIS

A Rapid Method of Analysis and Evaluation of Lubricating Grease, F. E. Chamberlin, C. F. Carter, J. L. Dreher, 10, XXII, January, 1959

ANTI-FRICTION

Ball and Roller Bearing Lubrication, R. S. Barnett, 12, XXII, March, 1959

APPLICATION

Modern Methods of Lubricant Application, E. J. Gesdorf, 4, XXII, July, 1958

EXTREME PRESSURE

Development of Extreme Pressure Greases, R. K. Smith, 9, XXII, December, 1958

HIGH TEMPERATURE

Development of an Extreme High Temperature Grease, J. W. Armstrong, H. A. Woods, 1, XXII, April, 1958

MANUFACTURE

The Mechanisms of Dispersion, K. H. Birkett, 11, XXII, February, 1959

The Mixing Efficiency of Grease Kettles, A. Beerbower, E. O. Forster, J. J. Kolfenbach, H. G. Vesterdal, 5, XXII, August, 1958

Some Practical Benefits of Mechanical Disperson, J. J. Dickason, 11, XXII, February, 1959

NON-SOAP THICKENERS

A Preformed Organic Thickener for Lubricating Greases, W. L. Hayne, Jr., J. E. Kline, T. P. Traise, 12, XXII, March, 1959

Pyrogenic Silica-Thickened Greases, Peter B. Marsden, 5, XXII, August, 1958

TESTING

CRC Laboratory Technique for Determining Rust-Preventive Properties of Lubricating Greases, E. W. Adams, 4, XXII, July, 1958

Discussion of "The Ordnance Corps Looks Into Grease Bleeding," R. H. Leet, A. C. Borg, 2, XXII, May, 1958

Field Testing of Automotive Chassis Greases, C. L. Knapp and J. Panzer, XXII, 7, October, 1958

Flow Properties of Lubricating Oils Under Pressure, S. J. Hahn, H. Eyring, I. Higuchi, T. Ree, 3, XXII, June, 1958

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Scientific Detection in Grease Lubrication Problems, R. J. Ronan and M. C. McLaren, 10, XXII, January, 1959

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MARKETING

Current and Future Military Grease Requirements, R. J. Horwath, 10, XXII, January, 1959

Future Lubricating Grease Requirements in the Steel and Underground Coal Mining Industries, J. C. Van Gundy, 11, XXII, February, 1959

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Packaging—An Essential Service, A. D. Murphy, 3, XXII, June, 1958

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Social Maturity for the Corporation, R. P. Dinsmore, 8, XXII, November, 1958

Two Tons of Grease, J. W. Waite, 12, XXII, March, 1959

Your Drum Can Make More Trips, Allen A. Armitage, 1, XXII, April, 1958

STRUCTURE

A New Equation for Calculating Flow of Lubricating Greases, D. W. Criddle, 8, XXII, November, 1958

WHEEL BEARINGS

Recommended Practices for Lubricating Automotive Front Wheel Bearings, 1, XXII, April, 1958

Literature and Patent Abstracts

Equipment

Deaerating and Dehydrating Lubricating Greases

A continuous method for deaerating lubricating grease consists of continuously forcing the lubricant through spreader plates, having elongated and tapered slots (see Figure 1) narrowing to widths of 0.006 to 0.02 inch, into a vacuum chamber. This chamber, in which a vacuum of 23 to 28 inches of mercury is maintained, is tall enough so that an accumulation of the deaerated lubricating grease permits of continuous withdrawal of the finished product.

According to Brooks and Piazza (U. S. Patent 2,797,767) 14,000 pounds per hour of a lubricating grease, having a worked penetration of 340, were pumped through such an apparatus. In this case the spreader plate was eight inches square with seven parallel, V-shaped slots, each six inches long and having a width, at the narrow portion, of 0.020 inch. The distance from the spreader plate to the entrance of the discharge pump was 5½ feet and the level of the deaerated material in the chamber during operation was four feet above the pump entrance. The chamber was made from a fourteen inch diameter pipe.

The same apparatus handled 8000 pounds per hour of a fibrous product having a worked penetration of 280.

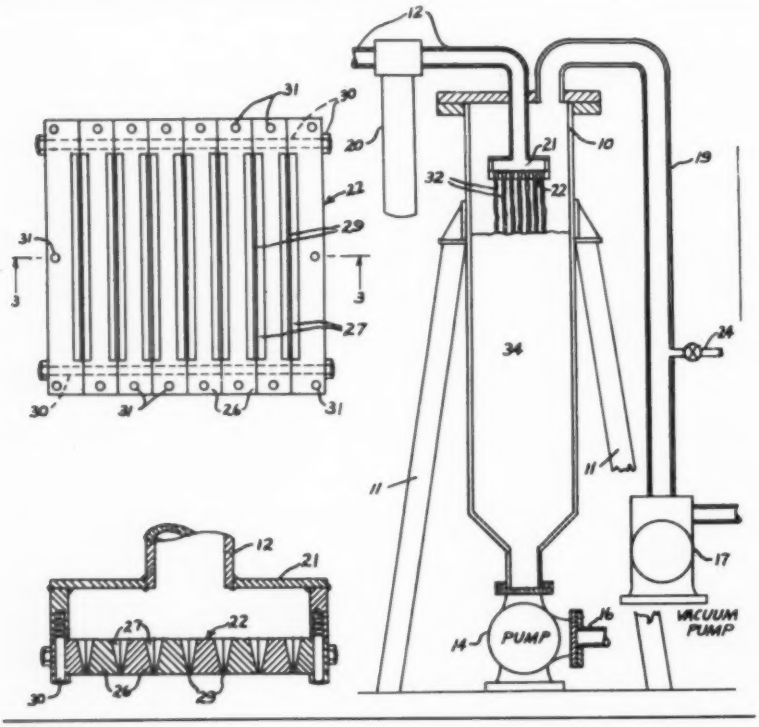

FIGURE 1

Analysis

An Extraction Procedure for The Determination of the Metallic Constituents in Greases

Larry A. Harrah, Wright Air Development Center, May 1958. PB 151027. One gram of the lubricating grease is dispersed in 29 ml. of benzene after which it is mixed with 15 ml. of 6N hydrochloric acid to remove the metal portions of the soap. Another similar treatment with hydrochloric acid and then a water wash are combined and made up to 100 ml.

This solution is run by a direct method of flame photometry to give the percents of metals present. The instrument is standardized by chlorides of metals dissolved in distilled water.

The precision of the method is in the order of 97 to 99 per cent, calcium showing the greatest variation and sodium the least variation from actual metal content of lubricating greases.

Reviews

Bearings, Lubricants and Lubrication—A Digest of 1957 Literature

Mechanical Engineering 80, p. 64-74, September 1958. This review, which is given annually by ASME, contains a bibliography of over 200 references. Several of these are concerned specifically with lubricating greases and six with gear lubrication.

Tests

Effect of Capillary Length-to-Diameter Ratio on Grease Viscosity

Miller, Walsh and Slaymaker. *Lubrication Engineering* p. 216-220, May 1958. Six sodium base lubricating greases, varying in soap content from 4.5 to 26.1 per cent, and one lithium base lubricant with a soap content of five to seven per cent were tested in a capillary tube

viscometer where the capillaries had length to diameter ratios of 40:1, 100:1, 250:1, 500:1, and 1000:1. The three samples having over 19 per cent soap but containing oils of a viscosity of 440 SUS at 100°F. changed in apparent viscosity about 13 to 19 per cent as the length ratio increased from 40 to 250 but for greater lengths there was little change in apparent viscosity. In the case of lubricating greases with less soap but with oils of 1200 to 4213 SUS at 100°F. the corresponding increases were 20 to 27.5 per cent. Lowering the test temperature from 75 to 40°F. caused about a ten per cent increase in apparent viscosity.

Theory

The Formation and Stability of Non-Soap Lubricating Greases

I. Factors Responsible for Gel Formation.

G. J. Young and J. J. Chessick. *J. Colloid Sci.* v. 13, pp. 358-71 (1958). Both synthetic fluids and petroleum base lubricating oils were thickened with titanium dioxide, different carbon blacks, different silicas, clays, or copper phthalocyanine.

It was found that the amount of hydrophobic (water hating) thickener required for a given penetration of lubricating grease was inversely proportional to the square of the surface area of the thickener. Hydrophilic (water loving) products were found to be more effective thickeners than hydrophobic bodying agents but the thickening ability of the former could not be correlated with the surface area.

The hydrophilic thickeners were found to be very sensitive to water as far as bodying power was concerned. If water was removed entirely from lubricating greases made with such thickeners, fluids resulted. Even the humidity of air influences such systems. Ethylene glycol acts much the same as water in this regard.

II. The Mechanism of Gel Formation.

J. J. Chessick, A. C. Zettlemoyer and G. J. Young. Ibid. pp. 372-8. The effect of polarity on thickening value of the above compounds was investigated by the addition of octane, 1-chloroheptane, 1-heptanol, caprylaldehyle, caprylic acid, or heptylamine to lubricating greases previously formed.

The polar additives had a thinning effect on hydrophobic silica products made with nonpolar oils and on carbon black products made with ethylene glycol but not on carbon black products made with non-polar oils. Carbon blacks had the greatest thickening action in the most polar oils. Both the heptanol and heptylamine thinned lubricating greases made from hydrophilic silicas and paraffin or polyester oils. This thinning could be reversed by subsequent addition of water.

Application

Proper Selection and use of Lubricants For Lubricated Plug Valves

R. Fred Klein, *Plant Engineering* 12, p. 94-5, Aug. 1958. Plug valve lubricants, which are available in either stick form or in bulk, serve

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Future Meetings

APRIL, 1959

5-10 American Chemical Society 135th National Meeting.

15-17 National Petroleum Association, Semi-annual Meeting, Hotel Cleveland, Cleveland, Ohio.

21-23 ASLE Annual Meeting and Exhibit, Hotel Statler, Buffalo, New York.

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MAY, 1959

4-6 API Division of Marketing, Lubrication Committee Meeting. San Marcos Hotel, Chandler, Ariz.

15-24 International Petroleum Exposition.

27-29 API Division of Marketing, Mid-year Meeting. The Savery, Des Moines.

31-June 6 Fifth World Petroleum Congress. The Coliseum, New York City.

JUNE, 1959

1-5 Fifth World Petroleum Congress Exposition, The Coliseum, New York City.

8-9 Petroleum Packaging Committee Meeting, Cleveland, Ohio

14-19 SAE Summer Meeting, Chalfonte-Haddon Hall, Atlantic City, N. J.

21-26 ASTM Annual Meeting Chalfonte-Hadden Hall, Atlantic City, N. J.

OCTOBER, 1959

26-28 NLGI Annual Meeting, Roosevelt Hotel, New Orleans, La.

11-15 ASTM Committee D-2 Meeting, Sheraton - Palace Hotel, San Francisco.

12-13 Petroleum Packaging Committee Meeting, Port Arthur, Texas

19-21 ASLE and ASME Joint Lubrication Conference, Sheraton-McAlpine Hotel, New York City.

28-30 Society of Automotive Engineers, National Fuels and Lubricants, La Salle Hotel, Chicago.

NOVEMBER, 1959

9-11 API, 39th Annual Meeting, Conrad Hilton, Palmer House and Congress Hotels, Chicago

APRIL, 1960

19-21 ASLE Annual Meeting and Exhibit, Netherland-Hilton Hotel, Cincinnati, Ohio.

APRIL, 1961

11-13 ASLE Annual Meeting and Exhibit, Bellevue Stratford Hotel, Philadelphia, Pa.

OCTOBER, 1961

30-Nov. 1 NLGI Annual Meeting, Edgewater Beach Hotel, Chicago, Illinois.

4-6 API division of Marketing, Lubrication Committee Meeting.

15-17 National Petroleum Association, Semianual Meeting.

26-27 API Division of Marketing, Lubrication Committee Meeting.

27-29 API Division of Marketing, Midyear Meeting.

to reduce friction, prevent the plug from sticking, and combat corrosion. They should be chosen for insolubility in the line contents and ability to adhere to the metal seating surfaces. While such products should have sufficient body to seal against leakage, plug valve lubricants must not harden when in place and should be chosen for operation at whatever temperature range necessary. In some cases color of the lubricant is a factor so as not to discolor the contents of the line. No compositions are mentioned.

Composition

Calcium Base Lubricating Greases Containing Wax

If, after a conventional calcium base lubricating grease is formed, the mass is cooled below 212°F, and preferably to 140 to 212°F, before the addition of paraffin wax, the soap proportion required for a given penetration will be reduced. Thus, Reudink (U.S. Patent 2,845,-409, assigned to Shell Development Co.) formed a lubricating grease from 13.5 parts of fatty acids, 86.5 parts of lubricating oil and 2.1 parts of hydrated lime. After being cooled to 176°F and while stirring the mass, 102 parts of a paraffin cracked residue were added. Since this latter fraction had a m.p. of 136.5°F, it was heated to 158°F before use.

The resulting lubricating grease, with a calculated fatty acid content of 6.7 per cent, had worked penetration of 218 and a dropping point (Ubbelohde) of 203°F.

In the case of similar combinations in which the wax was added before saponification only a fluid mass resulted in the final mixture.

Lubricating Grease Wherein the Thickener Is a Metal Salt of N-Acylaminoorganocarboxylic Acid

Hotten (U.S. Patent 2,852,466, assigned to California Research Corp.), suggests the above thickener for use in anti-friction bearings at temperatures up to 300 or 400°F. This is used in a concentration of 10 to 20 per cent. Barium, lithium and sodium are the preferred metals used.

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Thus, n-dodecanoylaminohexanoic acid was formed from 200 grams of lauric acid and 113 grams of epsilon-caprolactam by heating and stirring at 250°C. for 2½ hours, after which the mass was cooled to room temperature. The resulting product was twice crystallized from benzene, followed by washing with diethyl ether to give a brown powdery solid, containing 5.83 per cent nitrogen and having a neutralizing number of 143.

A mixture of 28.4 grams of the above acid and 170 grams of a California naphthenic oil having a viscosity of 450 SSU at 100°F. was mixed at 250°F. After cooling the mixture to 100°F., 2.9 grams of sodium hydroxide dissolved in 20 ml. of water were added followed by milling through a Manton-Gaulin homogenizer and then heating to 350°F. After two more passes through the homogenizer the resulting lubricating grease had a dropping point of 380°F. and a worker penetration of 260.

Lubricating Greases Containing Sulfonic Acid Soap

Lubricating oils can be thickened to a grease consistency with five to 30 per cent of an oil-insoluble soap of a straight chain aliphatic sulfonic acid containing ten to 20 carbon atoms in aliphatic portion. A metal soap of a high molecular weight fatty acid or a metal salt such as an acetate can also be included as a portion of the thickener. Sodium compounds are preferable.

The acid may be derived from olefins resulting from cracking of petroleum wax or petrolatum or from ployolefins. For example a mixed petrolatum which had been cracked was fractionated and the portion boiling between 70-170°C. was sulfonated and converted to sodium sulfonate.

To 150 grams of this soap was added 250 grams of an oil with a viscosity of 40 SUS at 210°F. After heating to 100°F. while agitating, an aqueous solution of 100 grams of sodium acetate was added. This mixture was then heated to 225°F. where dehydration occurred and where 500 grams of the oil was added. Continued heating to 500°F. gave a fluid which was allowed to cool undisturbed. A hard smooth cake resulted which when stirred and filtered gave a smooth cohesive product which had an unworked penetration of 200, a worked penetration of 240 and a dropping point of 380°F.

A similar lubricating grease, containing ten per cent of the sodium sulfonate and five per cent of sodium soap of hydrogenated fish oil acids, had a worked penetration of 275 and a dropping point of 354°F.

Such compositions are described in U.S. Patent 2,854,408 by Brugmann et. al. and assigned to Esso Research & Eng. Co.

Stabilizing Additives for Sodium Base Lubricating Greases

Sodium base lubricating greases containing high V.I. oils are stabilized at high temperatures and against the influence of mechanical working by the addition of 0.1 to 2 per cent of certain alcohol-substituted amides. Bidault (U.S. Patent 2,854,410, assigned to Esso Standard Societe Anonyme Francaise) used as such a stabilizer the condensation product obtained from: amines of soya fatty acids and five mols. of ethylene oxide; amines of coconut fatty acids with 50 mols. of ethylene oxide; or amines of tallow fatty acids with fifteen mols. of ethylene oxide.

Thus, a lubricating grease was made from 15 per cent stearic acid, 2.5 per cent caustic soda, 1 per cent phenyl alpha naphthylamine, and 81.5 per cent of a mineral oil with a viscosity of 150 SUS at 37.8°C. and a V.I. of 105. The soap-oil mixture was heated to 225°C. and poured into pans to cool. This resulted in a separation of the soap and oil after cooling.

A second lot of the same mixture was made and in this was included 0.25 per cent of the last condensation product mentioned above. Upon pan cooling a homogeneous cake resulted which did not sweat oil and which, after working.

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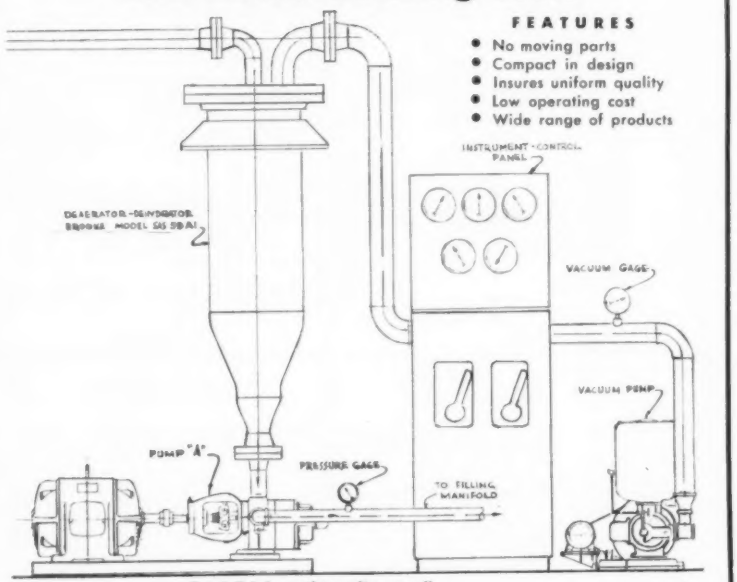

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formed a lubricating grease of 265 worked penetration which separated 0.37 per cent after 50 hours at 100°C.

Gear Lubrication

International Conference on Gearing—London

September 23-25, 1958. At this meeting one session was set aside for discussion of lubrication. *Scientific Lubrication*, V. 10, No. 10, October 1958, pp. 15-28, gives extended abstracts of four of the papers presented at that time. The high points of some of these will be mentioned.

Lubrication As a Gear Design Factor

By Prof. H. Blok. From the design standpoint of gears, the lubricating oil is just as important as the steel. By considering the lubricant from this standpoint scuffing damage can be reduced in gears. No specific gear lubricant specifications are given.

Lubrication of Spur Gears

By J. R. Hughes and F. H. Waight. The authors attempt to derive equations empirically which will predict failure of lubricants with speeds and loads. Data were accumulated by use of an I.A.E. 3¼-in. centers gear lubricant testing machine. Various coded E.P. additives were used in this investigation and, in general, the load-carrying capacity of an oil increased as more E.P. additive was added. However, a limit is reached beyond which there is no further improvement. It was concluded that it is very difficult to say to what extent laboratory results and practical experience agree.

The Choice of Gear Lubricants

By H. J. Watson. After a listing of typical examples of gears, scuffing loads with various lubricants on disc machine tests are given. It is concluded that while results from tests in the existing lubricant testing machines are of use as preliminary indication of desirable qualities in a gear lubricant, these machines do not entirely simulate gear operating conditions.

Extreme-Pressure Lubricant

Fainman in U.S. Patent 2,834,732, assigned to Standard Oil Co. of Indiana, describes the manufacture and use of lead-sulfurized tall oil as an E.P. agent. For example tall oil was heated with 10 per cent of sulfur at 330°F for 12 hours followed by further heating to 175°F after the addition of 5 per cent butyl Cellosolve, 75 per cent water and 33.5 per cent lead oxide. After this lead oxide was dissolved in three to four hours the product was drained and dried. When 10 per cent of this additive was added to oil the lead content was 2.8 per cent and the sulfur content 1.13 per cent. This mixture had a load-bearing capacity of 50 to 55 pounds on the Timken wear test.

Types of Gear Lubricants and Methods Of Application in Steel Mills

A summary of the types of gear lubricants available and also the methods of application is given in *Lubrication* (The Texas Company) October 1958 pp. 141-142.

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People in the Industry

R. L. Reep Is Named District Representative

Richard L. Reep has been named by American Potash & Chemical corporation as San Francisco district representative for the company's industrial chemicals.

Announcement of the appointment was made by William M. Clines, western general sales manager, who said Reep will report to Rod Taft, San Francisco district sales manager, and will cover northern California, northern Nevada, Utah and Colorado. Reep has been with the company since January, 1957.

Bruce Campbell was named to take over Reep's activities as representative for industrial chemicals in the Los Angeles area. Campbell joined the company in May, 1957.

Metasap Appoints Licata Technical Manager

The appointment of Francis J. Licata as technical manager of the Metasap Chemical company's sales department has been announced by Thomas J. Campbell, manager of Metasap, a subsidiary of Nopco Chemical. Mr. Licata will be responsible for the development of new markets and new uses for metallic soaps.

Now in his thirtieth year with Nopco, Mr. Licata is well known in the metallic soaps industry and holds many patents in the field. He has delivered numerous talks and written several articles on metallic soaps and their uses in various industries.

A graduate of City College of New York, he holds a B.S. degree in chemical engineering. He has also done post-graduate work at Columbia university and Brooklyn Polytechnic Institute.

Mr. Licata is a member of the American Chemical Society, American Institute of Chemists, Society of the Plastics Industry, the American Oil Chemists Society, and the Society of Plastics Engineers. He is also a member The Society of the Chemical Industry in London, England, and is listed in American Men of Science.

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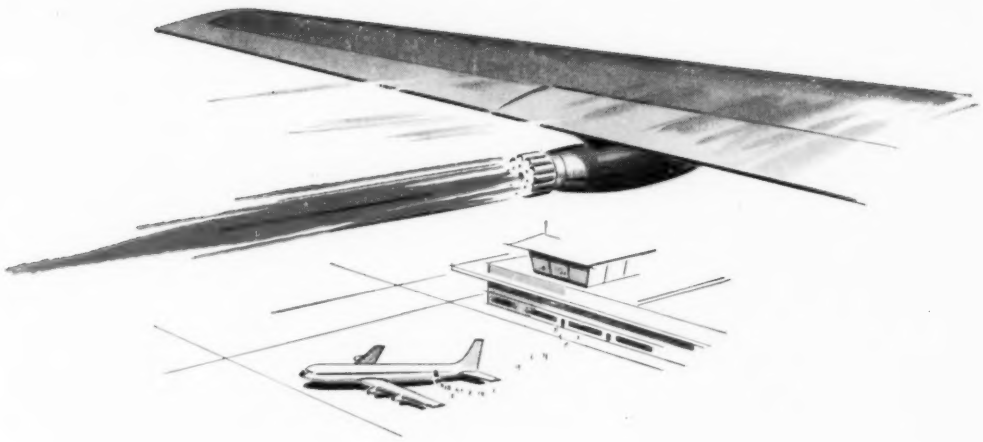

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Industry News

Research Management Selections Announced By Houghton

Dr. Ellis Abrams and Paul J. Welsh have been promoted to assistant managers of research by E. F. Houghton & Co., Philadelphia, suppliers of oils, packings, and chemicals, a further move in the company's long range program of expansion and new product development.

Responsibility for supervision of textile, paper, and organic research goes to Dr. Abrams who was formerly supervisor of organic research. Mr. Welsh, previously manager of product development, will supervise the company's research in metal working, rust preventives, and lubrication.

The new appointments were announced by Dr. R. K. Smith, Houghton's manager of research.

Long Appointed Production Chief by Girdler Catalysts

Appointment of Murrell D. Long as production superintendent was announced by Girdler Catalysts, Louisville, Ky., a unit of Chemetron corporation's chemical products division.

Girdler Catalysts is a leading U. S. manufacturer of specialty catalysts for petroleum and chemical process applications. Its plant is at 6000 Crittenden drive, Louisville. Long was with the firm from 1952 to 1957 and has been a field engineer with Wheelabrator corporation, Chattanooga, Tenn., for the past two years.

A native of Louisville, Long graduated from Colorado School of Mines in 1950 with the degree of petroleum engineer. He was with Sun Oil company at Morganfield, Ky., and the U.S. Geological Survey at Denver, Colo., before joining Girdler Catalysts in 1952.

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New Fibre Drum Line

Mr. S. A. Bennett, president of Bennett Industries, Inc., Peotone, Illinois, announced the start of production on new fibre drums under the trade name "Speedy-Pak." Bennett Industries are nationally known for their steel pails and drums, and for their fabricated structural steel and plate as well as their structural assemblies.

The fibre drums are curently being manufactured in four diameters, 11¼", 12½", 14" and 15½", with capacities ranging from two gallons to 26 gallons, inclusive. Net weight packing range, 60 lb., 115 lb., 150 lb. and 225 lb. for dry and solid articles. Data sheets covering a full list of sizes are available.

Speedy-Pak construction embodies sidewalls from Fourdrinier Kraft linerboard, ends from cold rolled steel with a baked-on protective coating of sanitary varnish. Closures are conventional clip type lugs, attached to the drum body. Unique features include vertical stacking, with a protective flange bottom area.

Mr. A. J. Gasbarra, vice president and general manager, Mr. R. R. Ernst, container general sales manager, and Mr. A. J. Godshalk, manager of the fibre drum division, feel that they now have all the usual problems of new lines licked and are turning out top quality fibre drums. Mr. Godshalk has been in the fibre drum business for approximately thirty years and in this new capacity at Bennett Industries he has been able to incorporate his experience and knowledge.

New "Hi-Stacker" Utility Can Eases Handling Problems

"Hi-Stacker," an important new development in utility shipping containers for lubricating oils, chemicals and other liquid products, designed to ease filling, handling, storing and shipping problems, is now being made available by Continental Can company. Fitted with a reversible pouring spout that is stored inside the can during shipment, this new electrically welded side-seam can is constructed to incorporate the advantages of Continental's present popular dome style container and duplicate its appearance when the spout is reversed and placed in pouring position. Offered in 2½-gallon, 5-gallon and 40-pound fluid grease sizes, all of which meet ICC shipping

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regulations, the "Hi-Stacker" container may be lithographed with a sales boosting design.

Savings in time, space, filling and shipping costs are achieved with the "Hi-Stacker." The can eliminates the need for reshipping cartons because of its self-storing spout that rides inside the can safely and clinches on the outside easily for fast, smooth dispensing. Less shipping and storing space is required by the "Hi-Stacker" which may be stacked on end, rolled and palletized.

Gulf Scientists Unlock Secrets of Lube Oil's Molecular Make-up

Scientists of Gulf Oil corporation have discovered a way to materially extend present knowledge of the molecular composition of lubricating oils. Their achievement will help make possible the improved lubricants needed in the coming age of ever higher operating temperatures and pressures.

The method, interpretive in nature, provides new and useful information on how the molecular make-up of lubricating oils relates to their performance. Molecular make-up actually determines the qualities of oil, such as viscosity, pour point, resistance to oxidation and others, but has hitherto defied analysis in the vast majority of cases.

The oil scientists' unlocking of these secrets is expected to lead to lubricants with molecular characteristics which produce specifically desired standards of performance. For the first time, it will be practical to tailor oils for improved effectiveness in particular jobs by the arrangement of their molecules.

Besides laboratory formulation of such superior oils, the Gulf technique can be applied to identifying, by molecular composition, the petroleum stock charged to refineries, and to correlating the appropriate stocks and processes to better produce oils for specific functions.

The significance of this development lies in the increasing severity of demands being made for lubrication under tremendous pressures, heats up to 600° F., and extreme tolerances in aircraft, rockets, and industrial processes. These requirements are expected to rise steeply in the future.

In the past it was practical to produce by refinery distillation (fractionation) a series of oils with a sufficient range of characteristics to fill most industrial and military needs. The oil worked; although from the viewpoint of scientific analysis of the material, no one knew why.

As this rule of thumb method grew less satisfactory under the demands for more severe lube uses, Gulf scientists undertook a pure research project to learn more about the molecular composition of lubricants.

Baffling difficulties loomed because lube oils are mixtures of many large molecules of which thousands of different species exist. Because of their complexity very few of these lube compounds have ever been isolated in pure form, so that no reliable data existed on their behavior of identification.

The first step was to literally tear the molecules apart by subjecting them to collisions with electrons in an instrument called the mass spectrometer. The molecular fragments were then collected and measured.

Fundamental research established that the number of fragments produced is directly related to the total number of valence electrons in a molecule. The valence electrons are those which circulate around the nuclei of the carbon and hydrogen atoms making up a lube oil molecule and hold them together. This led to scientific correlations between the number of fragments and the size of a lube oil molecule. Also the types of fragments produced were found to be related to the ways in which the carbon and hydrogen atoms are tied together to form the molecules.

This type of information made possible the engineering of the new techniques for identifying the types of molecules in lube oils.

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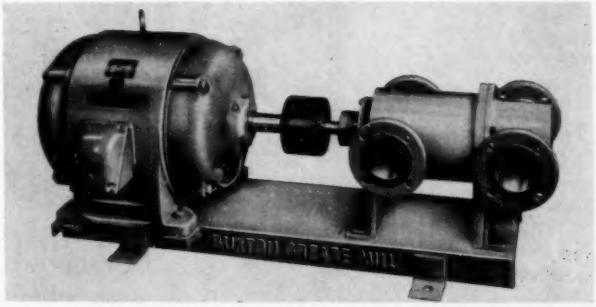

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Use of the mass spectrometer in analytical functions of this kind is not new. It has long been applicable to producing similar information on refinery gas and gasoline mixtures, where pure compounds are available for comparing molecular relationships. However, such compounds have not existed for lube oils.

The Gulf scientists, while not alone in researching the lube composition field, scored a basic breakthrough in their method of applying a mass spectrometer technique to this purpose. They are among the pioneers in "making sense" from the mass spectrometer data on lube oils and in relating it to the structure of the lube molecules.

New Plastic Pail Handle Developed by Vulcan Containers Inc. to Protect Containers in Transit

A new plastic handle grip for steel shipping pails has been developed to reduce possible damage to the lithographed, decorated or paint finish caused by abrasion during loading and in transit. The resilient new plastic grip is more comfortable to handle and prevents injuries since it will not break or splinter, a problem with conventional wooden handle grips.

Designed by Vulcan Containers Inc., pioneer steel shipping container manufacturer, of Bellwood, Ill., the new grip is highly resilient and will not scratch, dent or mar either the pail it is attached to or adjacent pails.

Vulcan designed the plastic grip to replace traditional wooden and metal grips which may deface customer trade mark colors, lithographed advertising and product labels on pails during rail or truck shipment.

Extensive tests by an independent container and material laboratory subjected both plastic and wooden handle grips to simulated crosscountry freight car rides. The plastic handle grips did not damage container surfaces, while the wooden grips wore painted surfaces down to bare steel within fifteen minutes.

The new plastic grip is virtually indestructible. After extensive research, Vulcan engineers selected a special blend of plastic that is resilient, yet retains the essential strength characteristics to meet the company's requirements for durability.

Unique in the container industry, the handle is designed with nine, tiny, full length air passages to provide a comfortable, cushioned grip. The special plastic material is non-absorbent and will not retain or transfer poisonous or corrosive material.

According to Lawrence M. Ferguson, Vulcan vice president of sales, the new plastic handle will be standard equipment on all Vulcan pails at no increase in cost. Detailed information from Vulcan Containers Inc., Dept. PR1, Bellwood, Ill.

Alpha-Molykote Announces New Compound

Molykote "Wear In" Compound, a new molybdenum disulfide compound which offers distinct advantages in the reduction of damage during "wearing in" (breaking in) of new machinery, has been announced by the Alpha-Molykote corporation.

The new compound: 1) shortens

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Molykote "Wear In" Compound was developed to improve on the outstanding "wear in" characteristics of another molybdenum disulfide product, Molykote, Type G. The new development was made possible when new testing equipment, designed and built by The Alpha-Molykote Corporation, became available.

Complete details are available from the Alpha-Molykote corporation, Stamford, Conn.

Lincoln Announces New Catalog of Power Lubrication Systems

A 32-page catalog published by Lincoln Engineering company is just off the press. It describes the industry's most complete line of lubricant application equipment, fittings and accessories, according to the manufacturer. Included are descriptions of completely automatic centralized systems, semi-automatic and manual methods of lubricating machines. In addition there are such fittings and accessories as: air couplers, hose, filters, air gauges, valves and pressure switches—in fact, all equipment necessary to automate or modernize a lube program is cataloged. Application can be made on any kind of machine that has a bearing surface (rotating, sliding or reciprocating) which requires a lubricant.

Ask for Catalog No. 81 from Lincoln Engineering company, 5703-30 Natural Bridge avenue, St. Louis 20, Missouri.

New Eighty Foot Distillation Unit Now in Use

An eighty foot distillation tower has just gone on stream at the Franklin, Pa., refinery of L. Sonneborn Sons, Inc., petroleum refiners and manufacturing chemists.

Primary purpose of the new distillation unit is to meet increased demand for the Franklin refinery's production of specialty solvents that are manufactured as important by-products in the refining of Amalie lubricating oils.

The major raw material for Amalie lubricating oils — principle products of the Sonneborn refinery — is Pennsylvania Grade crude oil, which is not only an outstanding source of lubricants but also yields high quality by-products. Among these by-products are petrolatum, microcrystalline wax, and specialty solvents.

The 80-foot tower, which weighs 30 tons, was erected by outside contractors, with pipe-fitting, installation, and steel work handled by the Refinery's own construction crew.

Sonneborn, an important factor in the petroleum products field, has sold its lubricants for fifty years under the "Amalie" brand name. It is a leader in the field of white oil and petrolatum; and its petroleum sulfonates find wide application in a variety of industrial uses.

Girdler Construction Division Consolidates Louisville Offices

Girdler construction division of Chemetron corporation, which designs, engineers and builds process plants and equipment for chemical, petroleum and gas process industries, announced it has consolidated its headquarters offices in a single location, the Commonwealth building, in downtown Louisville, Ky., engineering, sales, purchasing and accounting departments are all in the same building. Mail address for Girdler construction division is P. O. Box 174, Louisville, Ky.

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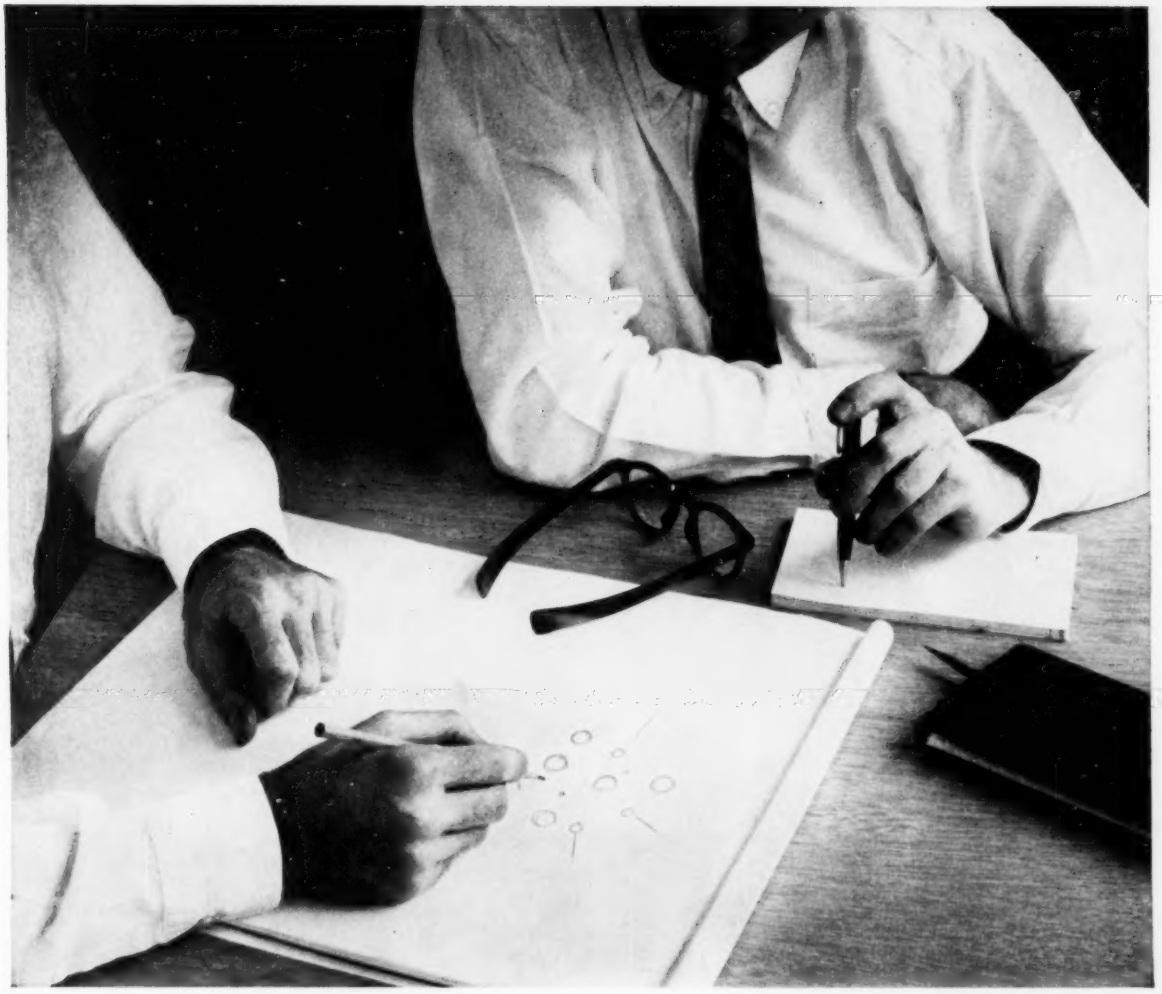

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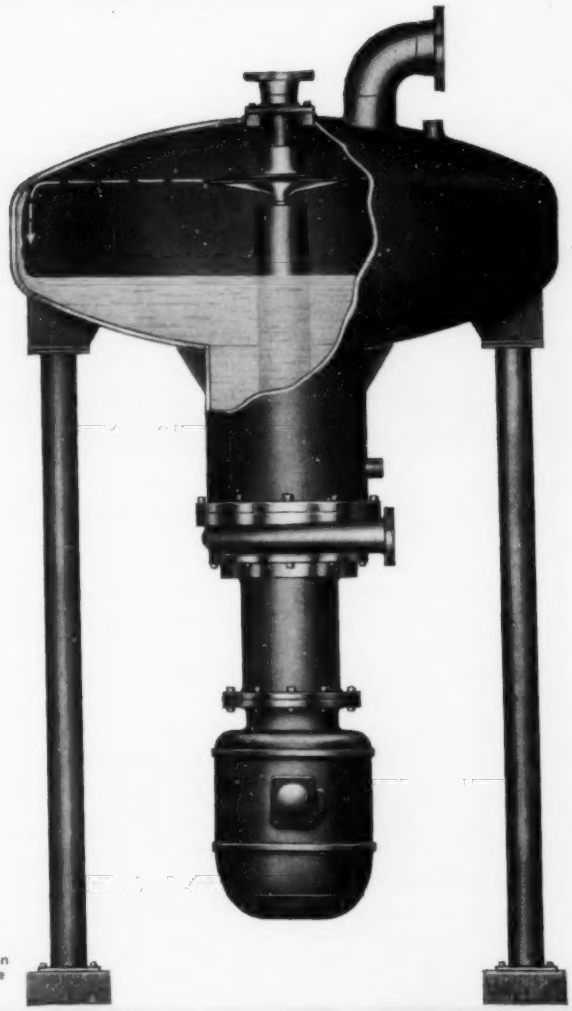

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